ILLUSTRATING BASIC

(A SIMPLE PROGRAMMING LANGUAGE)

DONALD ALCOCK

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To my sons:

Andrew

and

Gavin

CONTENTS

PREFACE

TO MAKE A COMPUTER DO A CALCULATION — HOWEVER SIMPLE — YOU MUST FIRST DESCRIBE EVERY STEP OF THAT CALCULATION IN A *LANGUAGE* THE COMPUTER CAN UNDERSTAND; THIS DESCRIPTION IS CALLED A *PROGRAM*. THIS BOOK PRESENTS A POPULAR AND WIDELY AVAILABLE LANGUAGE CALLED *BASIC* AND EXPLAINS HOW TO WRITE SIMPLE PROGRAMS IN IT.

ALTHOUGH MORE ELEGANT AND POWERFUL LANGUAGES ARE FAVOURED BY PROFESSIONAL PROGRAMMERS *BASIC* IS ADEQUATE FOR MOST NON-PROFESSIONALS AND EXCELLENT FOR BEGINNERS.

BASIC WAS BORN IN AMERICA AT DARTMOUTH COLLEGE, NEW HAMPSHIRE, IN 1964 AS A SIMPLE COMPUTER LANGUAGE FOR BEGINNERS. IT PROVED POPULAR AND HAS BEEN COPIED AND EXTENDED BY MANY COMPUTER MAKERS, COLLEGES, UNIVERSITIES AND "TIME-SHARING" SERVICES. NOW, LIKE ENGLISH, *BASIC* HAS *DIALECTS*: A PROGRAM WRITTEN IN ONE IS UNLIKELY TO WORK ON A COMPUTER COMMITTED TO ANOTHER.

THERE IS SOON TO BE A STANDARD FOR "MINIMAL BASIC" BY THE AMERICAN NATIONAL STANDARDS INSTITUTE † (A.N.S.I. X3J2), AND "SPECIFICATION FOR STANDARD BASIC" BY BULL, FREEMAN & GARLAND HAS BEEN PUBLISHED BY THE NATIONAL COMPUTING CENTRE, U.K.* (1976). THESE HAVE NOT YET HAD TIME TO ENCOURAGE EVERYONE TO FALL INTO LINE SO THE *BASIC* YOU MEET WILL PROBABLY NOT BE STANDARD. I HAVE ACCEPTED THIS AS A FACT OF LIFE, AND, IN WRITING THIS BOOK, KEPT AT MY SIDE ELEVEN MANUALS — EACH DEFINING A DIFFERENT *BASIC*. FOUR OF THESE VERSIONS ARE AVAILABLE ON BIG COMPUTERS OPERATED BY INTERNATIONAL "TIME-SHARING" SERVICES; THE OTHER SEVEN ON COMPUTERS RANGING FROM BIG TO "DESK-TOP". FROM THESE ELEVEN MANUALS I HAVE TRIED TO DISCOVER AND POINT OUT WHERE *BASICS* COMMONLY DIFFER FROM ONE ANOTHER AND RECOMMEND WAYS OF AVOIDING DEPENDENCE ON ANY ONE PARTICULAR VERSION. I HAVE USED THE WORD "PORTABLE" TO DESCRIBE A *BASIC* PROGRAM WRITTEN WITH INDEPENDENCE IN MIND — AND TREAT THE NEED FOR PORTABILITY AS AN AXIOM.

† A.N.S.I. X3J2/76-01 ISSUED FOR PUBLIC COMMENT IN JANUARY 1976

★ REFERRED TO IN THE TEXT AS "N.C.C. STANDARD BASIC"

YOU DON'T HAVE TO BE A COMPUTER SCIENTIST TO READ THIS BOOK; IT IS FOR STUDENTS MEETING COMPUTERS FOR THE FIRST TIME; FOR THOSE IN INDUSTRY (PARTICULARLY ENGINEERS) WHO NEVER FORMALLY STUDIED COMPUTING BUT WOULD LIKE TO WRITE SIMPLE COMPUTER PROGRAMS; FOR MANAGERS WHO DO NOT WANT TO WRITE PROGRAMS BUT WOULD LIKE TO KNOW MORE ABOUT A FIELD IN WHICH THEY OFTEN HAVE TO TAKE DECISIONS; AND FOR THOSE WHO CAN ALREADY WRITE IN *BASIC* BUT SEEK A BROADER VIEW OF "PORTABLE" PROGRAMMING AND AN INTRODUCTION TO A FEW PROGRAMMERS' TECHNIQUES LIKE "STATE TABLES" AND "LIST PROCESSING".

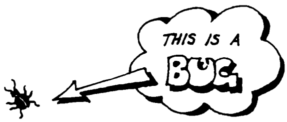
THE TEXT OF THE BOOK IS ARRANGED FOR THE MOST PART IN DOUBLE-PAGE SPREADS, EACH DEALING WITH A SINGLE "STATEMENT" OF THE *BASIC* LANGUAGE. BECAUSE SO MANY STATEMENTS ARE INTERDEPENDENT THIS ARRANGEMENT DEMANDS FORWARD REFERENCES NOW AND AGAIN, BUT NOVICES TO COMPUTING MAY IGNORE FORWARD REFERENCES FIRST TIME THROUGH THE BOOK WITHOUT FEAR OF MISSING SOMETHING ESSENTIAL TO UNDERSTANDING THE SUBJECT MATTER.

I RECORD MY DEEP GRATITUDE TO THREE PEOPLE WHO MADE THIS BOOK POSSIBLE: MY WIFE, FAY, WHO SUFFERED GRASS-WIDOWHOOD BUT NEVER CEASED HER WARM ENCOURAGEMENT; MY PARTNER, BRIAN SHEARING, WHO HAS TAUGHT ME SO MUCH ABOUT COMPUTING AND ALLOWED ME TIME OFF WORK TO WRITE THE BOOK; AND CHARLES LANG WHO BELIEVED IN MY IDEAS AND PERSUADED ME TO GIVE THEM FORM.

MY BOOK IS INFORMAL IN LANGUAGE AND UNUSUAL IN PRESENTATION. RATHER THAN WRITE A JUSTIFICATION I WOULD ONLY REMARK THAT A CAREFUL READER MIGHT DIAGNOSE A SEVERE ASTIGMATISM IN MY EYE AND A PERSISTENT SHAKE IN MY HAND.

REIGATE,
SURREY, U.K.

Donald Alcock
JANUARY 1977



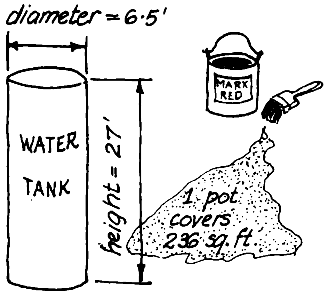
"*BUG*" IS COMPUTER JARGON FOR A MISTAKE. THE BOOK SHOWS THIS LITTLE BUG AGAINST ILLUSTRATIONS OF MISTAKES IN PROGRAMS.

1

COMPONENTS OF THE LANGUAGE

PROBLEM

HOW MANY POTS OF PAINT DO YOU NEED TO PAINT THE ROOF AND WALL OF THIS WATER TANK?



WE COULD GO STRAIGHT AT IT LIKE THIS:

roof area, $T = \pi \times 6{\cdot}5^2 \div 4 = 33{\cdot}2$
wall area, $S = \pi \times 6{\cdot}5 \times 27 = 551$
total area, $A = T + S = 584{\cdot}2$
number of pots, $G = A \div 236 = 2{\cdot}48$
rounding up, $R = 3$
∴ *you need 3 pots of paint*

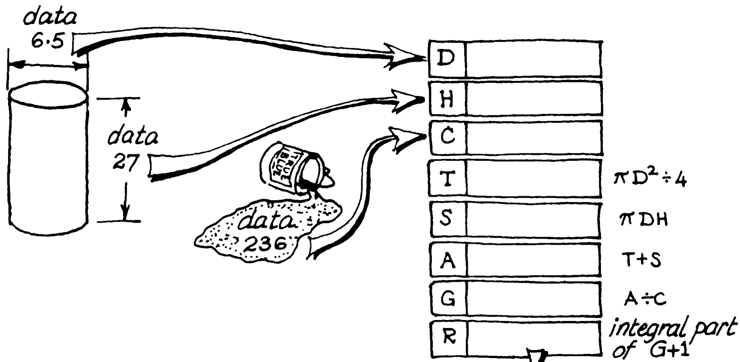
OR WE COULD WRITE A *PROGRAM* (IN ENGLISH) TO SOLVE THE PROBLEM..

1. **REMARK:** A PROGRAM IN ENGLISH
2. THE FOLLOWING NUMBERS ARE THE **DATA** 6·5, 27, 236
3. **READ** THE DATA, CALLING THEM **D, H & C** RESPECTIVELY
   (think of this as putting the data into little boxes labelled D, H & C respectively – see opposite page)
4. WORK OUT $3{\cdot}14 \times D^2 \div 4$ AND LET THE RESULT BE CALLED **T**
   (i.e. put the result in a little box labelled T)
5. WORK OUT $3{\cdot}14 \times D \times H$ AND LET THE RESULT BE CALLED S
6. ADD **T** TO **S** AND LET THE RESULT BE CALLED **A**
7. WORK OUT **A ÷ C** AND LET THE RESULT BE CALLED **G**
8. ROUND **G** TO THE NEXT WHOLE NUMBER AND LET THE RESULT BE CALLED **R**
   (i.e. add 1 to G and take the integral part of the result)
9. **PRINT** "YOU NEED" ; **R** ; " POTS"
   (i.e. print whatever whole number R turns out to be)
10. THE **END**

THIS HAS THE ADVANTAGE OF BEING GOOD FOR ANY SIZE OF TANK AND PAINT POT – YOU NEED ONLY REPLACE THE DATA ON LINE 2.

NOW

TRY *OBEYING* THE ENGLISH PROGRAM OPPOSITE, FEEL WHAT IT WOULD BE LIKE *TO BE* A COMPUTER, *DEFILE* THIS PAGE BY WRITING NUMBERS IN THE LITTLE BOXES BELOW.



HERE IS THE SAME PROGRAM AGAIN BUT WRITTEN IN **BASIC**.

COMPARE IT CAREFULLY WITH THE *ENGLISH* VERSION OPPOSITE.

```
1   REM   A PROGRAM IN BASIC
2   DATA  6.5, 27, 236
3   READ  D, H, C
4   LET   T=3.14*D↑2/4
5   LET   S=3.14*D*H
6   LET   A=T+S
7   LET   G=A/C
8   LET   R=INT(G+1)
9   PRINT "YOU NEED"; R ; "POTS"
10  END
```

notice

* meaning multiply

↑ meaning raise to a power

/ meaning divide

AND THIS, WHEN OBEYED, WOULD PRODUCE:

```
YOU NEED 3 POTS
```

FIRST PREPARE *YOUR* PROGRAM BY TYPING INSTRUCTIONS AT THE KEYBOARD — THE COMPUTER SIMPLY *STORES* THE PROGRAM AT THIS STAGE :

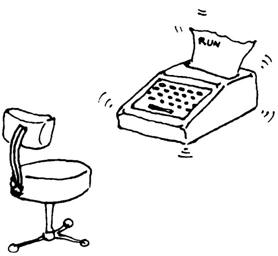
IT DOESN'T OBEY ANY INSTRUCTIONS

```
1 REM  A PROGRAM IN BASIC
2 DATA  6.5, 27, 236
3 READ  D, H, C
4 LET  T=3.14*D↑2/4
5 LET  S=3.14*D*H
6 LET  A=T+S
7 LET  G=A/C
8 LET  R=INT(G+1)
9 PRINT "YOU NEED";R;"POTS"
10 END
```

THEN TYPE RUN

WHICH SETS THE COMPUTER TO WORK *OBEYING* THE STORED INSTRUCTIONS ONE AFTER THE OTHER — IN NUMBERED SEQUENCE — WHILST YOU RELAX.

EVENTUALLY THE COMPUTER WILL OBEY THE INSTRUCTION END. THAT MAKES IT STOP.




```
RUN
YOU NEED 3 POTS
```

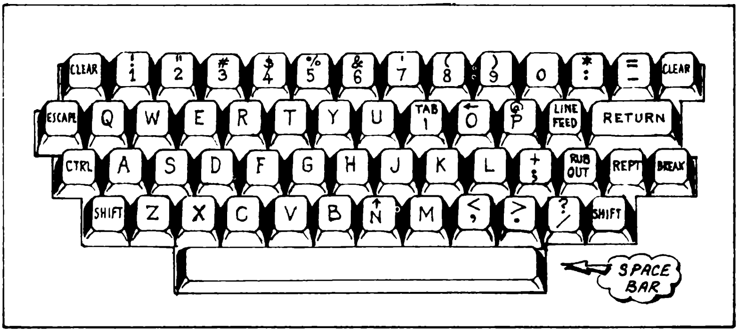
BUT BEFORE YOU CAN TAKE THE FIRST STEP AND START TYPING THE PROGRAM YOU HAVE TO GO THROUGH THE RITUAL OF *SIGNING ON* AND TELLING THE COMPUTER YOU WANT TO USE *BASIC*.

DIFFERENT COMPUTERS (EVEN IDENTICAL COMPUTERS RUN BY DIFFERENT ORGANISATIONS) OFTEN HAVE DIFFERENT WAYS OF DOING THESE THINGS, SO IF YOU WANT TO TRY THE PROGRAM NOW GET SOMEONE WHO "KNOWS THE SYSTEM" TO SIGN ON FOR YOU AND CALL UP *BASIC*.

KEYBOARD

EVERY PROGRAM IN *BASIC* HAS TO BE TYPED ON A KEYBOARD

PROBABLY SOMETHING LIKE THIS



ALTHOUGH POSITIONS OF LETTERS & DIGITS ARE THE SAME ON MOST KEYBOARDS, KEYS LIKE [RUB OUT] & [BREAK] IN THE PICTURE ABOVE VARY IN NAME, POSITION AND FUNCTION FROM ONE INSTALLATION TO ANOTHER.

NOTICE ALL LETTERS ARE CAPITAL LETTERS. NOTICE ALSO THERE IS A KEY FOR 1 AND A KEY FOR ZERO (BOTH IN THE TOP ROW). NEVER PRESS THE LETTERS I AND O IN THEIR PLACE.

AS ON AN ORDINARY TYPEWRITER, PRESSING [SHIFT] AT THE SAME TIME AS ANOTHER KEY GIVES THE CHARACTER SHOWN ON THE UPPER HALF OF THAT KEY: THUS [# 3] TOGETHER WITH [SHIFT] GIVES # WHEREAS [# 3] ALONE, 3.

THE "BACK ARROW" ← SERVES TO DELETE THE CHARACTER ON ITS LEFT FROM THE COMPUTER'S MEMORY; TWO OF THEM DELETE THE PREVIOUS TWO CHARACTERS, AND SO ON. THUS IF YOU TYPE PRIMP←←NT THEN *BASIC* RECEIVES THE WORD PRINT. (REMEMBER THIS BY EXCLAIMING *OH SHIFT!* WHEN YOU HIT THE WRONG KEY.) SOME *BASICS*, HOWEVER, USE AN UNDERSCORE CHARACTER FOR THIS PURPOSE: PRIMP__NT.

MOST *BASICS* USE A KEY (PERHAPS "RUBOUT") WHICH, WHEN PRESSED, DELETES THE WHOLE OF THE LINE YOU ARE TYPING FROM THE COMPUTER'S MEMORY; ANOTHER (PERHAPS "BREAK") STOPS A PROGRAM RUNNING.

FOR A *NEW LINE* IN *BASIC* PRESS [RETURN]

WHEN TYPING "OFF LINE" PRESS RETURN then LINEFEED

TYPING

IF YOU INTEND TO USE *BASIC* A LOT, LEARN TOUCH TYPING. TEN FINGERS ARE FASTER AND LESS FRUSTRATING THAN TWO.

THERE IS A LIMIT TO THE LENGTH OF A TYPED LINE: MOST *BASICS* ALLOW LINES UP TO 72 CHARACTERS LONG. SOME ALLOW LONGER LINES BUT IT IS BEST TO ACCEPT A LIMIT OF 72.

SOME *BASICS* ALLOW GREAT FREEDOM WITH THE SPACE BAR; SOME DISREGARD SPACES EXCEPT THOSE BETWEEN QUOTATION MARKS. THUS IT WOULD BE ALLOWABLE TO TYPE:

```
8FORD=STOP
```

INSTEAD OF:

```
8 FOR D = S TO P
```

BUT IT IS OBVIOUSLY SILLY TO OBSCURE THE MEANING OF THE PROGRAM IN ORDER TO SAVE A FEW TAPS ON THE SPACE BAR.

SOME *BASICS* REFUSE TO ALLOW SPACES WITHIN THE CONTROLLING WORDS OF THE LANGUAGE. THUS THE FOLLOWING WOULD BE WRONG:

```
23 L E T  A = B+C
```

SOME *BASICS* DEMAND AT LEAST ONE SPACE BEFORE EACH CONTROLLING WORD, OR AFTER IT, OR BOTH:

```
20DATA  6.5, 27, 236
80  PRINT"YOU NEED";R;"POTS"
```

SOME *BASICS* REFUSE TO ACCEPT SPACES WITHIN LINE NUMBERS BUT DO NOT OBJECT TO THEM INSIDE OTHER NUMBERS:

```
1 000  LET  A=1 000 . 0
1000  LET  A=1000.0
```

SOME BASICS OBJECT TO THESE TOO

SOME *BASICS* DO NOT ALLOW SPACES IN FRONT OF LINE NUMBERS:

```
  95  LET  A=B
 100  LET  C= D*F  + G
```

SPACES OPTIONAL HERE

GENERALLY WHEN *ONE* SPACE IS ALLOWED (OR DEMANDED) THEN *SEVERAL* ARE ALLOWED. AND GENERALLY A SPACE IS OPTIONAL ON EITHER SIDE OF THESE ⇒ (, ; * + / − = ↑ > <)
BUT NOT IN 1.5E2 (SEE PAGE 9) NOR BETWEEN > AND = (SEE PAGE 41).

A PROGRAM WHICH ACCEPTS ALL THESE RESTRICTIONS SHOULD BE ACCEPTABLE TO ANY VERSION OF *BASIC*.

LINE NUMBERS

LEAVE GAPS IN THEIR SEQUENCE THUS:

USE 10s OR 5s

```
10 REM     A PROGRAM IN BASIC
20 DATA    6.5, 27, 286←←36
30 READ    D, H, C
40 LET     T = 3.14 * D↑2/4
50 LET     S = 3.14 * D * H
60 LET     A = T + S
70 LET     G = A/C
80 PRINT "YOU NEED"; R; "POTS"
90 END
```

THIS IS 236. SEE PAGE 5

THERE IS A *MISTAKE* IN THIS PROGRAM: THE LAST LET WAS FORGOTTEN. INSERTING IT IS SIMPLE; JUST TYPE:

```
75 LET  R = INT (G+1)
```

AND THE COMPUTER PUTS LINE 75 BETWEEN LINE 70 & LINE 80. IT MAKES NO DIFFERENCE IN WHAT ORDER YOU *TYPE* THE LINES; THE COMPUTER SORTS THEM INTO ASCENDING ORDER OF LINE NUMBER.

IF YOU TYPE SEVERAL LINES WITH THE *SAME* LINE NUMBER THE COMPUTER OBLITERATES EACH PREVIOUS VERSION THUS ACCEPTING THE LINE TYPED LAST. IF THE LINE TYPED LAST IS *JUST* A LINE NUMBER WITH NOTHING AFTER IT THEN THE *WHOLE LINE VANISHES* FROM THE COMPUTER'S MEMORY — INCLUDING THE LINE NUMBER. THAT IS HOW TO DELETE UNWANTED LINES. THUS:

```
120 LET  A = B + C
125 LET  E = F
120 LET  A = B + G
125
120 LET  A = B
```

RESULTS IN THE COMPUTER REMEMBERING ONLY:

```
120 LET A = B
```

THE FIRST LINE NUMBER IN A PROGRAM MUST BE GREATER THAN 0. THERE IS ALWAYS A LIMIT TO THE HIGHEST LINE NUMBER: SOME *BASICs* STOP AT 9999, SO IT IS BEST TO ACCEPT THIS AS THE LIMIT.

THE *LAST* STATEMENT OF EVERY PROGRAM MUST BE: **END**
(NO OTHER STATEMENT BUT THE LAST MAY SAY END).

STATEMENTS

A *BASIC* PROGRAM IS A SEQUENCE OF NUMBERED LINES CALLED *STATEMENTS*.

A STATEMENT MAY SIMPLY *STATE* SOMETHING

```
110 DATA 1, 2, 4
120 END
```

```
30 READ A,B,C
40 LET G=A*B↑2 +C
50 PRINT "ANSWER IS";G
```

OR IT MAY *INSTRUCT* THE COMPUTER TO *DO* SOMETHING. A COMMON SYNONYM FOR *STATEMENT* IS *INSTRUCTION*; THE STATEMENTS THAT *DO* THINGS ARE *EXECUTABLE* INSTRUCTIONS.

THE COMPUTER FINDS OUT WHAT IS STATED OR WHAT TO DO BY LOOKING AT THE FIRST WORD: DATA, END, READ, LET *etc.*

OR SOMETIMES AT THE FIRST *TWO* WORDS: MAT READ, MAT PRINT *etc.* (WE MEET MAT ON PAGE 76).

BUT THERE IS AN IMPORTANT EXCEPTION:

THE WORD **LET** MAY BE *OMITTED* IN MOST VERSIONS OF *BASIC*.

```
40 G = A*B↑2 + C
```

REM

REM STANDS FOR *REMARK*.
REM STATEMENTS CAUSE NO ACTION BY THE COMPUTER; YOU INCLUDE THEM TO CLARIFY YOUR PROGRAM.

```
10 REM        *** WATER TANKS ***
20 REM
30 REM   A PROGRAM TO ILLUSTRATE BASIC
40 REM   -*-*-*-*-*-*-*-*-*-*-*-*-*-
50 DATA    6.5,     27,      236
60 REM   DIAM, HEIGHT, COVERAGE
```

REM FOR BLANK LINES

REM FOR EMBELLISHMENT

REM FOR CLARITY

THE EXAMPLES IN THIS BOOK DO NOT HAVE MANY "REM" STATEMENTS BECAUSE I HAVE ANNOTATED PROGRAMS WITH LITTLE ARROWS AND CLOUDS SO AS TO SAVE SPACE.

NUMBERS

YOU CAN TYPE NUMBERS THREE WAYS: AS *INTEGERS*, AS *REALS* OR IN *E-FORM*.

INTEGER FORM
(WHOLE NUMBERS)

```
160 DATA   0,  2, +4, 1000, -30
```

REAL FORM
(DECIMAL NUMBERS)

```
170 DATA +0.70, 4., .6, -1.3, 987.65
```

4. MEANS 4.0

E-FORM
(EXPONENT FORM)
WHERE *E* SAYS:
"TIMES TEN TO THE..."

```
190 DATA 1E3, 13.6E-4,-13.6E6,-.0136E9
```

$1.0\times10^{3} = 1{,}000$ | $13.6\times10^{-4} = 0.00136$ | $-13.6\times10^{6} = -13{,}600{,}000$ | $-.0136\times10^{9} = -13{,}600{,}000$

E INTRODUCES AN *INTEGER* SAYING HOW MANY PLACES TO SHIFT THE DECIMAL POINT. SHIFT TO THE RIGHT IF THE INTEGER IS POSITIVE; OTHERWISE LEFT.

```
190 DATA  E3, 13.6E1.2 , 13.6 E 2
```

IN THE *E* FORM THERE MUST ALWAYS BE A NUMBER IN FRONT OF THE *E* AND AN *INTEGER* AFTER IT. SOME *BASIC*S ALLOW SPACES WITHIN AN *E* FORM BUT IT IS BEST NOT TO HAVE THEM.

$\pm10^{38}$

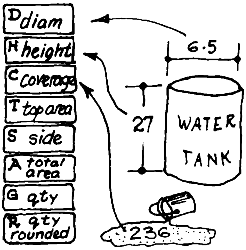
IN SOME *BASIC*S THE BIGGEST NUMBER THAT CAN BE STORED IS APPROXIMATELY $\pm10^{38}$ (*BIG* MEANS FAR FROM ZERO ON EITHER SIDE; *SMALL* MEANS CLOSE TO ZERO ON EITHER SIDE). OTHER *BASIC*S CAN HANDLE MUCH BIGGER NUMBERS THAN $\pm10^{38}$; IT DEPENDS ON THE COMPUTER'S "WORD LENGTH" AND WHETHER THE "WORDS" ARE USED SINGLY, IN PAIRS, OR IN MULTIPLES. BUT ***NO*** *BASIC* SHOULD REFUSE TO HANDLE A NUMBER AS BIG AS ±*100,000,000,000,000,000,000,000,000,000,000,000,000*.

6~7 SIG. FIG.

IN SOME *BASIC*S THE PRECISION OF STORAGE AND ARITHMETIC IS BETWEEN 6 AND 7 SIGNIFICANT DECIMAL DIGITS: 987,654,321 WOULD BE STORED AS APPROXIMATELY 987,654,000. OTHER *BASIC*S OFFER MUCH HIGHER PRECISION, 15 SIGNIFICANT FIGURES BEING TYPICAL. AGAIN IT DEPENDS ON THE COMPUTER'S "WORD LENGTH" AND HOW THE "WORDS" ARE USED. BUT ***NO*** *BASIC* SHOULD WORK TO LESS PRECISION THAN 6 TO 7 SIG. FIGS. (THE VAGUENESS OF "6 TO 7" IS BECAUSE MOST COMPUTERS USE BINARY ARITHMETIC, NOT DECIMAL. A MORE PRECISE RENDERING WOULD BE "24 BINARY DIGITS FOR POSITIVE NUMBERS; 23 FOR NEGATIVE; OR VICE VERSA" BUT THESE IMPLICATIONS NEED NOT BOTHER THE NOVICE TO *BASIC*.)

VARIABLES

THERE ARE 286 *SIMPLE* NUMERICAL VARIABLES IN *BASIC*.



WE SAW SOME OF THESE ON PAGE 3. THEY ARE THE LITTLE BOXES USED TO HOLD NUMBERS.

THE FULL 286 ARE SHOWN BELOW. IT IS USEFUL TO KEEP A LARGE-SCALE CHART LIKE THIS AND MAKE A PHOTOCOPY FOR EACH NEW PROGRAM. AS YOU USE EACH VARIABLE WRITE A NOTE IN ITS BOX SAYING WHAT YOU USE IT FOR. THIS STOPS YOU USING VARIABLES ALREADY USED FOR SOMETHING ELSE — A COMMON SOURCE OF TROUBLE.

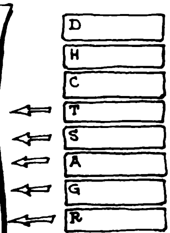
A	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9
B	B0	B1	B2	B3	B4	B5	B6	B7	B8	B9
C	C0	C1	C2	C3	C4	C5	C6	C7	C8	C9
D	D0	D1	D2	D3	D4	D5	D6	D7	D8	D9
E	E0	E1	E2	E3	E4	E5	E6	E7	E8	E9
F	F0	F1	F2	F3	F4	F5	F6	F7	F8	F9
G	G0	G1	G2	G3	G4	G5	G6	G7	G8	G9
H	H0	H1	H2	H3	H4	H5	H6	H7	H8	H9
I	I0	I1	I2	I3	I4	I5	I6	I7	I8	I9
J	J0	J1	J2	J3	J4	J5	J6	J7	J8	J9
K	K0	K1	K2	K3	K4	K5	K6	K7	K8	K9
L	L0	L1	L2	L3	L4	L5	L6	L7	L8	L9
M	M0	M1	M2	M3	M4	M5	M6	M7	M8	M9
N	N0	N1	N2	N3	N4	N5	N6	N7	N8	N9
O	O0	O1	O2	O3	O4	O5	O6	O7	O8	O9
P	P0	P1	P2	P3	P4	P5	P6	P7	P8	P9
Q	Q0	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9
R	R0	R1	R2	R3	R4	R5	R6	R7	R8	R9
S	S0	S1	S2	S3	S4	S5	S6	S7	S8	S9
T	T0	T1	T2	T3	T4	T5	T6	T7	T8	T9
U	U0	U1	U2	U3	U4	U5	U6	U7	U8	U9
V	V0	V1	V2	V3	V4	V5	V6	V7	V8	V9
W	W0	W1	W2	W3	W4	W5	W6	W7	W8	W9
X	X0	X1	X2	X3	X4	X5	X6	X7	X8	X9
Y	Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9
Z	Z0	Z1	Z2	Z3	Z4	Z5	Z6	Z7	Z8	Z9

REPLACEMENT

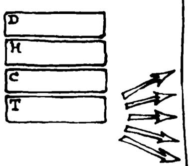
YOU MAY USE EACH VARIABLE MANY TIMES.

PUTTING A NUMBER INTO A VARIABLE SIMPLY REPLACES THE ONE ALREADY THERE. COMPARE THE FOLLOWING TWO PROGRAMS; THE FIRST IS THE ONE ON PAGE 3 WITH NEW LINE NUMBERS:

```
10 REM A PROGRAM IN BASIC
20 DATA 6.5, 27, 236
30 READ D, H, C
40 LET T = 3.14 * D↑2/4
50 LET S = 3.14 * D * H
60 LET A = T + S
70 LET G = A/C
80 LET R = INT(G+1)
90 PRINT "YOU NEED"; R; "POTS"
100 END
```



THE SECOND DOES THE SAME JOB BUT USES VARIABLE T OVER AND OVER AGAIN:




```
10 REM TO ILLUSTRATE REPLACEMENT
20 DATA 6.5, 27, 236
30 READ D, H, C
40 LET T = 3.14 * D↑2/4
50 LET T = T + 3.14*D*H
60 LET T = T/C
70 LET T = INT (T+1)
80 PRINT "YOU NEED"; T; "POTS"
90 END
```

WHEN A PROGRAM STARTS RUNNING EVERY VARIABLE HAS SOME INITIAL VALUE; IT DEPENDS ON THE VERSION OF *BASIC* WHAT THAT VALUE IS. IN SOME *BASICS* IT IS **ZERO**; IN SOME IT IS WHATEVER THE PREVIOUS PROGRAM LEFT BEHIND; IN OTHERS IT IS A SPECIAL SIGNAL TO SAY **VARIABLE NOT SET**. SO IN THE FOLLOWING COMPLETE PROGRAM:

```
10 PRINT V
20 END
```

YOU MIGHT GET 0 OR RUBBISH LIKE −123.456 OR A MESSAGE FROM THE COMPUTER TO SAY IT CANNOT GO ON BECAUSE VARIABLE V IS NOT SET WHEN FIRST USED.

DON'T RELY ON ANY VARIABLE BEING ZERO WHEN THE PROGRAM STARTS; SET IT FIRST:

```
10 LET V=0
```

TEXTS

BASIC CAN HANDLE *WORDS* AS WELL AS NUMBERS. WE SAW THIS ON PAGE 4.

```
9  PRINT "YOU NEED"; R; "POTS"
10 END
RUN
YOU NEED 3 POTS
```

THE "YOU NEED" AND THE "POTS" ARE CALLED *TEXTS* IN THIS BOOK. OTHER TERMS IN THE JARGON ARE: *STRING*; *LITERAL STRING*; *ALPHAMERIC STRING*; *ALPHAMERIC LITERAL*; AND THERE MAY BE MORE.

TEXTS ARE WORDS OR SENTENCES OR ARRANGEMENTS OF CHARACTERS ENCLOSED IN QUOTATION MARKS. BY THIS DEFINITION YOU CAN'T HAVE A TEXT CONTAINING QUOTATION MARKS BECAUSE THE COMPUTER WOULD THINK THEY MARKED THE END OF IT; BUT YOU CAN HAVE APOSTROPHES IN TEXTS:

```
20 PRINT "IT'S EASY"
```

HOWEVER, SOME *BASICS* ALLOW TEXTS TO BE ENCLOSED BETWEEN APOSTROPHES AS AN OPTION; SUCH TEXTS MAY HAVE QUOTATION MARKS IN THEM BUT NOT APOSTROPHES. OTHER *BASICS* GET ROUND THE PROBLEM BY TREATING A *PAIR* OF QUOTATION MARKS INSIDE A TEXT AS SIGNIFYING A SINGLE QUOTATION MARK:

```
30 PRINT "SHE SAID ""OOH!"""
```

PRODUCES:

```
SHE SAID "OOH!"
```

BUT IT IS BEST TO AVOID HAVING QUOTATION MARKS IN TEXTS.

SEMICOLONS IN THE "PRINT" STATEMENT MAKE THE COMPUTER ABUT THE THINGS TO BE PRINTED ONE AGAINST THE OTHER; COMMAS WOULD MAKE THE COMPUTER SPREAD THEM OUT ACROSS THE PAGE. ALL THIS IS EXPLAINED FROM PAGE 28 ON, WHERE THE "PRINT" STATEMENT IS EXPLAINED IN DETAIL.

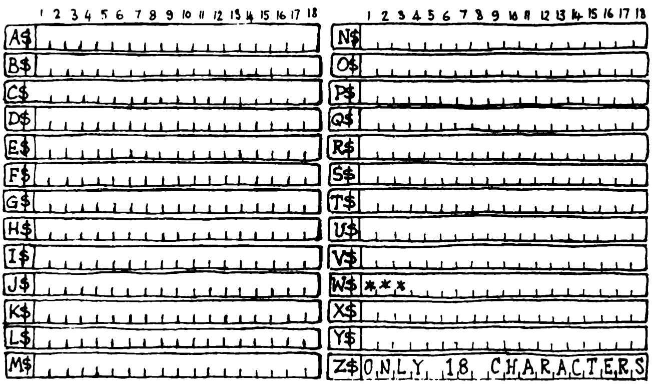
TEXTS IN THE "PRINT" STATEMENT MAY BE OF ANY LENGTH THAT WILL FIT THE LINE BEING TYPED. IF YOU WANT SOMETHING PRINTED RIGHT ACROSS THE OUTPUT PAGE YOU MUST PRINT TWO OR MORE TEXTS, ALL BUT THE LAST HAVING A SEMICOLON AFTER THEM.

```
120 PRINT "------------------------";
130 PRINT "------------------------";
140 PRINT "------------------------"
```

TEXTUAL VARIABLES

IN ADDITION TO THE 286 LITTLE BOXES FOR STORING NUMBERS THERE ARE AT LEAST 26 FOR STORING TEXTS; THESE ARE CALLED *TEXTUAL VARIABLES*. WE HAVE COINED THIS TERM TO BALANCE *NUMERICAL VARIABLE* BUT OTHER TERMS IN THE JARGON ARE: *TEXT VARIABLE*, *STRING VARIABLE* & *LITERAL VARIABLE*.

EVERY *BASIC* HAS A LIMIT TO THE LENGTH OF TEXT THAT CAN BE STORED IN A TEXTUAL VARIABLE: SOME ALLOW AS MANY AS 4095 CHARACTERS; OTHERS AS FEW AS 18 ⇄ A MAXIMUM FOR "PORTABILITY".



SOME *BASICS* HAVE 286 TEXTUAL VARIABLES: A$, A0$, A1$, A2$, *etc. to* Z8$, Z9$.

WHEN THE PROGRAM STARTS, TEXTUAL VARIABLES MAY CONTAIN BLANKS; OR TEXTS LEFT OVER FROM A PREVIOUS PROGRAM; OR SPECIAL SIGNALS TO SAY *VARIABLE UNSET*. AS WITH NUMERICAL VARIABLES (PAGE 10) IT DEPENDS ON THE *BASIC* BEING USED. SET VARIABLES BEFORE READING FROM THEM IF YOU WANT TO WRITE A "PORTABLE" PROGRAM.

TEXTUAL VARIABLES MAY BE SET BY "LET" STATEMENTS:

```
10   LET   W$ = "***"
20   LET   Z$ = "ONLY 18 CHARACTERS STORED"
```

AND PRINTED USING "PRINT" STATEMENTS:

```
30   PRINT   W$; Z$; W$
40   END
RUN
***ONLY 18 CHARACTERS***
```

LIMIT TO FIT INTO TEXTUAL VARIABLE

TEXTUAL VARIABLES MAY ALSO BE SET BY "READ" (PAGE 16) AND BY "INPUT" (PAGE 18). THEY MAY BE COMPARED BY "IF" (PAGE 41).

```
50   IF   I$ = "YES"   THEN  80
60   IF   I$ = W$      THEN  9000
```

2

INPUT & OUTPUT, EXPRESSIONS AND FUNCTIONS

DATA + READ

THE DATA STATEMENT PROVIDES RAW NUMBERS AND TEXTS FOR READ STATEMENTS TO FEED ON. YOU MAY HAVE ANY NUMBER OF **DATA** STATEMENTS ANYWHERE IN A PROGRAM. BEFORE STARTING WORK THE PROGRAM JOINS THEM TOGETHER TO FORM ONE LONG "QUEUE". THERE IS NOTHING TO *OBEY* IN A **DATA** STATEMENT, BUT AS THE COMPUTER OBEYS A **READ** STATEMENT IT PICKS UP AS MANY ITEMS AS IT NEEDS FROM THE FRONT OF THIS QUEUE LEAVING THE REMAINDER FOR SUBSEQUENT **READ** STATEMENTS.

THE FOLLOWING TWO PROGRAMS BOTH PRODUCE THE RESULT SHOWN AT THE END OF THE SECOND PROGRAM.

```
10 REM      UNBROKEN   QUEUE
20 DATA   "ODDS", 7, -23, -17, "EVENS", -12, 36
30 READ    Q$,  B,  C, D,   E$,  E, F
40 PRINT   Q$;  B;  C; D;   E$;  E; F
50 END
```

```
10   REM     FRAGMENTED  QUEUE
20   DATA   "ODDS", 7
30   READ  Q$, B, C, D, E$, E, F
40   DATA    -23, -17
50   PRINT  Q$;B;C;D;E$;E;F
60   DATA    "EVENS", -12, 36
70   END
RUN
ODDS 7  -23  -17 EVENS-12   36
```

IT IS UP TO YOU TO PUT NUMBERS AND TEXTS WHERE THEY WILL BE READ BY VARIABLES OF THE RIGHT KIND. THE FOLLOWING PROGRAM WOULD FAIL WHILE READING N. (ONE OR OTHER PAIR SHOULD BE REVERSED.)

```
10   DATA    "ANNO", 1977
20   READ      N,   C$
30   PRINT     N;   C$
40   END
```

SOME *BASICS*, HOWEVER, CREATE SEPARATE QUEUES FOR NUMBERS AND TEXTS — THIS EXAMPLE WOULD WORK. BUT SEPARATE QUEUES ARE UNUSUAL.

IF THERE ARE MORE "READS" THAN ITEMS THE COMPUTER PRINTS A MESSAGE SAYING IT HAS RUN OUT OF DATA AND STOPS WORK.

```
10 DATA  1.5, 2.5, -3.5, 4
20 READ  A, B
30 READ  C, D, E
40 PRINT  A; B; C; D; E
50 END
RUN
* OUT  OF  DATA  AT  LINE  30 *
```

RESTORE

THE RESTORE STATEMENT BRINGS YOU BACK TO THE FRONT OF THE QUEUE OF ITEMS FORMED FROM ALL THE DATA STATEMENTS.

WHEN THE COMPUTER OBEYS A **READ** STATEMENT IT READS AS MANY ITEMS AS IT NEEDS FROM THE FRONT OF THE QUEUE AND LEAVES THE REMAINDER FOR SUBSEQUENT **READ** STATEMENTS. BUT IT DOESN'T *DESTROY* THE QUEUE. INDEED ON MEETING A **RESTORE** STATEMENT THE COMPUTER JUMPS BACK TO THE VERY FRONT OF THE QUEUE AND OBEYS THE NEXT **READ** STATEMENT FROM THERE.

```
10  DATA  1,2,3,4,5,6,7,8,9
20  READ  A,B,C
30  PRINT  A;B;C
40  READ  A,B,C
50  PRINT  A;B;C
60  RESTORE
70  READ  A,B,C
80  PRINT  A;B;C
90  END
RUN
1  2  3
4  5  6
1  2  3
```

THESE NEVER GET READ AT ALL

N.C.C. "STANDARD BASIC" USES THE WORD "RESET"

ITEMS

ITEMS IN DATA STATEMENTS MAY BE *NUMBERS* (WITH OR WITHOUT + & − SIGNS), OR *TEXTS*, OR BOTH; BUT NOT *EXPRESSIONS* (SEE PAGE 20).

```
10  REM   NUMBERS AND TEXTS ALLOWED
20  DATA  1.5, +16.28, -13.47, "YES", "NO"
30  REM   EXPRESSIONS FORBIDDEN
40  DATA  3.14*6.5↑2/4
```

ITEMS MUST BE SEPARATED FROM EACH OTHER BY COMMAS. THERE IS NO COMMA AT THE END OF EACH LIST.

IF A TEXT IS TOO LONG FOR THE VARIABLE THEN THE EXTRA CHARACTERS ARE LOST:

```
10  DATA  "FAR TOO LONG FOR THE VARIABLE"
20  READ  V$
```

THE LAST CHARACTER STORED IN V$

SEE PAGE 13

IN THE ORIGINAL *DARTMOUTH BASIC* THE ONLY WAY TO GET DATA INTO A PROGRAM WAS BY THE **DATA** STATEMENT. MOST *BASICS* TODAY HAVE THE MORE POPULAR **INPUT** STATEMENT AS WELL. THE **INPUT** STATEMENT IS EXPLAINED OVERLEAF.

INPUT

YOU CAN MAKE A *BASIC* PROGRAM ASK FOR DATA: IT RESTS IN SUSPENSE WHILST YOU TYPE A LINE.

```
10    REM     ILLUSTRATING INPUT
20    PRINT   "TYPE ME A NUMBER"
30    INPUT   X
40    PRINT   "YOU JUST TYPED"; X
50    END
RUN
TYPE ME A NUMBER
?
```

THE PROGRAM IS RESTING AT STATEMENT 30 WAITING FOR DATA. IT WILL WAIT INDEFINITELY UNTIL YOU TYPE SOME DATA AND PRESS THE RETURN KEY. (SOME *BASICS* MAY SHUT DOWN AFTER A WHILE IF THEY GET NO RESPONSE.)

```
? 6.5
YOU JUST TYPED 6.5
```

THE INPUT STATEMENT MAY NEED MORE THAN ONE NUMBER:

```
30 INPUT X,Y,Z        ⇨   ? 6.5, 7.5, 8.5
```

IT CAN INPUT TEXTS AS WELL:

```
40 INPUT A$, B$       ⇨   ? "REVELATIONS", "THE APOCRYPHA"
```

AND A MIXTURE OF NUMBERS & TEXTS:

```
30 INPUT T$, C, V     ⇨   ? "ROMANS", 15 , 4.2
```

BUT WHATEVER THE INPUT STATEMENT NEEDS, THE MANNER OF ASKING (CALLED THE PROMPT) IS THE SAME: IN SOME *BASICS* JUST A RING ON THE BELL; IN OTHERS A QUESTION MARK; IN OTHERS AN ARROW OR "GREATER THAN" SIGN.

```
♫ |            |    ? |            |    > |            |
```

SO TO HELP THE USER OF A PROGRAM (WHO MAY NOT BE ITS AUTHOR) YOU SHOULD PRECEDE EVERY INPUT STATEMENT WITH AN EXPLANATORY PRINT STATEMENT:

```
25    PRINT   "TYPE A TEXT & A NUMBER"
30    INPUT   T$, C
```

[WHEN VARIABLES HAVE SUBSCRIPTS (SEE PAGE 64) YOU MAY INPUT & USE THEIR VALUES FROM LEFT TO RIGHT: *e.g.* INPUT I,J,A(I,J) .]

WHAT HAPPENS IF YOU TYPE SOMETHING WRONG IN RESPONSE TO A PROMPT?

UNFORTUNATELY THERE ARE DIFFERENT ACTIONS BY DIFFERENT *BASICS*.

TOO MUCH DATA: YOU ARE ASKED TO RETYPE THE WHOLE LINE.

```
10 INPUT A,B,C
```

```
? 10, 20, 30, 40, 50
TOO MUCH DATA; RETYPE LINE
?
```

BUT SOME *BASICS* JUST *IGNORE* THE EXTRA NUMBERS; OTHERS *SAVE* THEM FOR THE NEXT INPUT STATEMENT OR DO SO ONLY IF THE LINE OF DATA ENDS WITH A COMMA.

NOT ENOUGH DATA: YOU ARE ASKED TO RETYPE THE WHOLE LINE.

```
20 INPUT A,B,C,D,E
```

```
? 10
NOT ENOUGH DATA; RETYPE LINE
?
```

BUT SOME *BASICS* SIMPLY CONTINUE PROMPTING UNTIL THEY HAVE ENOUGH DATA.

MISMATCHING: YOU ARE ASKED TO RETYPE THE WHOLE LINE.

```
30 INPUT T$,C,V
```

```
? "ROMANS", 15, "SIX"
WRONG KIND OF DATA; RETYPE LINE
?
```

BUT SOME *BASICS* WOULD ACCEPT THE FIRST TWO ITEMS ABOVE AND RE-PROMPT ONLY FOR THE THIRD; SOME *BASICS* WOULD STOP THE PROGRAM ALTOGETHER.

TEXTS: IF A TEXT HAS NO SPACES IN IT THEN YOU ARE ALLOWED TO LEAVE OUT THE QUOTATION MARKS:

```
40 INPUT T$, C
```

```
? ROMANS, 15
```

BUT SOME *BASICS* DO NOT ALLOW THIS; SOME WOULD EVEN STOP THE RUN.

IF A TEXT IS TOO LONG FOR THE VARIABLE THEN YOU ARE ASKED TO RETYPE THE WHOLE LINE:

```
50 INPUT T$, C
```

```
? "THE GOSPEL ACCORDING TO ST.JOHN",2
TEXT TOO LONG; RETYPE LINE
?
```

BUT SOME *BASICS* WOULD SIMPLY TRUNCATE THE OVER-LONG TEXT.

SOME *BASICS* ALLOW TEXTS ENCLOSED WITHIN APOSTROPHES; SEE PAGE 12.

COMMAS & SPACES: THE TYPED LIST SHOULD HAVE COMMAS BETWEEN ITEMS AND NO SPACES INSIDE ITEMS. SOME *BASICS* PERMIT COMMAS TO BE OMITTED BUT INSIST ON PROPER SPACING (SEE PAGE 6); OTHERS DISREGARD SPACES (EXCEPT IN TEXTS) BUT INSIST ON THE COMMAS.

EXPRESSIONS

YOU CAN WRITE EXPRESSIONS OF GREAT COMPLEXITY IN *BASIC*.

HERE IS AN EXAMPLE OF AN EXPRESSION ⇨ THE PAINTED AREA OF THE WATER TANK ON PAGE 2.

3.14 * D↑2/4 + 3.14 *D *H

GIVEN D=6.5, H=27, IF YOU WERE ASKED TO EVALUATE THIS EXPRESSION YOU WOULD CERTAINLY *NOT* START BY WORKING OUT 4+3.14=7.14 NOR 2/4=0.5 THEN 0.5+3.14=3.64

WHY NOT? BECAUSE OF CONVENTIONS WE ALL ACCEPT:

☆ EXPONENTIATION COMES FIRST:	DO	6.5^2 =	42.25
☆ THEN MULTIPLICATIONS & DIVISIONS:	DO	3.14×42.25 =	132.665
	THEN	132.665 ÷ 4 =	33.1663
	THEN	3.14 ×6.5 =	20.4100
	THEN	20.4100×27 =	551.07
☆ FINALLY ADDITIONS & SUBTRACTIONS:	DO	33.1663+551.07=	584.236

AND THAT IS PRECISELY HOW BASIC DOES IT.

HERE IS THE SAME FORMULA EXPRESSED DIFFERENTLY:

(3.14 * D * (D/4 +H))

YOU MAY "NEST" BRACKETS TO ANY REASONABLE DEPTH. THE COMPUTER EVALUATES THE EXPRESSION IN THE INNERMOST PAIR OF BRACKETS AND WORKS OUTWARDS ⇨ PRODUCING THE RESULT YOU WOULD EXPECT BY THE RULES OF ALGEBRA.

THERE IS NO IMPLIED MULTIPLICATION; YOU CAN'T DO THIS:

3.14 D(D/4+H)

AND YOU MAY NOT PUT TWO OF THESE THINGS ⇨ ↑ / * − + NEXT TO ONE ANOTHER WITHOUT A BRACKET INTERVENING:

3.14*+D*(+D/+4 +H)

O.K. A BRACKET INTERVENES

HOW DO YOU EXPRESS 10^{-2}? NOT AS 10↑−2, BUT AS 10↑(−2) OR 1/(10↑2).

ON TYPING EXPRESSIONS YOU MAY SPACE OUT OR BUNCH UP AS YOU PLEASE:

```
10  LET   A   =  3.14  *  D↑2  /  4   +3.14*D*H
```

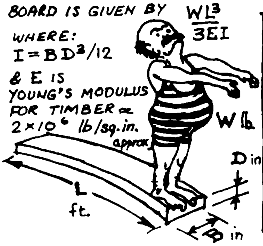
RULES FORBIDDING SPACES IN KEYWORDS & LINE NUMBERS ARE GIVEN ON PAGE 6.

( ) CLARIFY EXPRESSIONS BY USING BRACKETS EVEN WHEN NOT STRICTLY NECESSARY.

WHAT IS A/B/C ? MOST *BASICS* TREAT IT AS (A/B)/C BUT SOME AS A/(B/C). (TRY 8/4/2 BOTH WAYS AND SEE THE DIFFERENCE.) ALWAYS USE BRACKETS TO MAKE SURE THE COMPUTER EVALUATES AN AMBIGUOUS EXPRESSION THE WAY YOU INTEND.
A↑B↑C IS ANOTHER AMBIGUOUS EXPRESSION: (A↑B)↑C OR A↑(B↑C) ? AND A^{2M} SHOULD BE EXPRESSED A↑(2*M), NOT A↑2*M.

HERE ARE TWO PROGRAMS ILLUSTRATING EXPRESSIONS.

THE DEFLECTION OF A DIVING BOARD IS GIVEN BY $\frac{WL^3}{3EI}$
WHERE: $I = BD^3/12$
& E IS YOUNG'S MODULUS FOR TIMBER ≈ 2×10^6 *lb/sq.in. approx.*




```
10 PRINT "TYPE: W(LB), L(FT), B(IN), D(IN)"
20 INPUT        W,   L,   B,   D
30 LET   E = 2000000
40 LET   I = B*D↑3/12
50 LET   V = W*(L*12)↑3/(3*E*I)
60 PRINT "BOARD SAGS"; V; "INCHES"
70 END
```

```
10 PRINT "TYPE: SUM, YEARS, INTEREST%"
20 INPUT              S,     N,     P
30 LET   R = P/100
40 LET   M = S*R*(1+R)↑N/(12*((1+R)↑N-1))
50 PRINT "MONTHLY BURDEN = $" ; M
60 PRINT "YOU LOSE $"; M*(12*N)-S
70 END
```

THE MONTHLY REPAYMENT ON A MORTGAGE LOAN OF $S AT P% OVER N YEARS IS:

$$\frac{SR(1+R)^N}{12[(1+R)^N-1]}$$

WHERE: $R = P \div 100$.

SOME POINTS TO WATCH:

IF YOU WRITE "LET A=B/C" AND "C" TURNS OUT TO BE ZERO (OR SOMETHING VERY VERY SMALL) THE COMPUTER PRINTS A MESSAGE TO SAY "DIVISION BY ZERO" (OR "NUMBER TOO BIG"). IN SUCH CASES SOME *BASICS* THEN SUPPLY A RESULT FOR "A": THE RESULT BEING $\pm 10^{38}$ (OR BIGGER IF THE COMPUTER CAN STORE IT), THE *SIGN* BEING THAT OF THE NUMERATOR OF THE EXPRESSION CAUSING THE TROUBLE. ON THE OTHER HAND SOME *BASICS* STOP THE PROGRAM. OTHER *BASICS* SUPPLY THE BIG VALUE AS DESCRIBED ABOVE BUT DON'T REPORT THE TROUBLE.

−A↑B IN MOST *BASICS* IS TREATED AS −(A↑B). BUT IT IS BEST TO INCLUDE THE BRACKETS TO MAKE SURE.

A↑B IS TAKEN AS 1.0 IF B=0 AND A>0. THE PROGRAM STOPS IF A<0 ALTHOUGH SOME *BASICS* ALLOW IT WHEN B IS A WHOLE NUMBER.
A↑B GIVES 10^{38} (SEE ABOVE) IF A=0 AND B<0.

FUNCTIONS

IN ADDITION TO THE OPERATORS * / + ↑ *BASIC* PROVIDES *FUNCTIONS* SUCH AS *SQUARE ROOT*.

YOU HAVE ALREADY SEEN AN EXAMPLE OF A FUNCTION ON PAGE 3:

```
8  LET  R = INT(G+1)
```

WHERE R ENDS UP AS THE INTEGRAL PART OF THE EXPRESSION INSIDE THE BRACKETS. THE EXPRESSION G+1 COULD BE MORE COMPLICATED; HERE IS THE WATER TANK PROGRAM AGAIN:

```
10 PRINT  "TYPE: DIAMETER, HEIGHT, COVERAGE"
20 INPUT         D,         H,        C
30 LET  T = INT(1+(3.14*D*(D/4+H))/C)
40 PRINT "YOU NEED"; T; "POTS"
50 END
```

THE EXPRESSION MAY ITSELF CONTAIN FUNCTIONS; EVEN THE SAME ONE:

```
10 INPUT  X
20 PRINT  SQR(SQR(ABS(X)))
30 END
```

WHICH IS A PROGRAM TO PRINT THE FOURTH ROOT OF THE POSITIVE VALUE OF A NUMBER.

A FUNCTION IN AN EXPRESSION MAY BE TREATED IN EXACTLY THE SAME WAY AS A NUMERICAL VARIABLE ⇒ WHEREVER YOU MAY TYPE X YOU MAY ALSO TYPE INT(X). YOU SHOULD NOT TYPE ANY SPACES IN THE NAME OF THE FUNCTION NOR BETWEEN THE NAME AND OPENING BRACKET; HOWEVER, SOME *BASICS* DO NOT OBJECT TO SUCH SPACES. THE EXPRESSION INSIDE THE BRACKETS MAY BE SPACED OUT OR BUNCHED UP.

MANY *BASICS* OFFER A GREAT VARIETY OF FUNCTIONS BUT ALL SHOULD OFFER AT LEAST THE STANDARD ELEVEN DESCRIBED HERE. THEY ARE CALLED *INTRINSIC* FUNCTIONS BECAUSE THEY ARE PART OF *BASIC* ITSELF. YOU MAY INVENT OTHER FUNCTIONS WHICH ARE NOT INTRINSIC AS EXPLAINED ON PAGE 26.

FUNCTIONS SGN(X), ABS(X), SQR(X), INT(X), LOG(X), EXP(X) ARE DESCRIBED OPPOSITE; THE TRIGONOMETRICAL FUNCTIONS SIN(X), COS(X), TAN(X) ARE DESCRIBED ON PAGE 24; PAGE 25 IS DEVOTED TO THE FUNCTION RND.

SGN(X) = +1 IF X > 0
= 0 IF X = 0
= −1 IF X < 0

"THE SIGN OF"

```
10 PRINT SGN(7.2); SGN(0); SGN(-.2)
```
⇒
```
1 0 -1
```

ABS(X) = +X IF X ≥ 0
= −X IF X < 0

"THE ABSOLUTE VALUE OF"

```
20 PRINT ABS(7.2); ABS(0); ABS(-.2)
```
⇒
```
7.2  0  0.2
```

SQR(X) = $\sqrt{X}$ IF X ≥ 0
= ERROR IF X < 0 (BUT SOME BASICS PRODUCE $\sqrt{-X}$)

"THE SQUARE ROOT OF"

```
30 PRINT SQR(16); SQR(0); SQR(-16)
```
⇒
```
4  0
ERROR: SQR(NEGATIVE)
```

INT(X)

"THE INTEGRAL PART OF"
(THE HIGHEST INTEGER LESS THAN OR EQUAL TO X)
(WHERE 0 IS "HIGHER" THAN −1)

```
40 PRINT INT(3.4);INT(-3.4);INT(3)
```
⇒
```
3  -4  3
```
N.B.

LOG(X) = $log_e(X)$ IF X > 0
= ERROR IF X = 0
= ERROR IF X < 0 (BUT SOME BASICS PRODUCE $log_e(-X)$)

"THE NATURAL LOGARITHM OF"

```
50 PRINT LOG(1); LOG(10); LOG(2.71828)
```
⇒
```
0  2.30258  1
```

EXP(X) = ε^X
(where $\varepsilon \doteq 2.71828...$)

"THE NATURAL ANTILOGARITHM OF"
"THE EXPONENTIAL OF"

```
60 PRINT EXP(0); EXP(2.30258);EXP(1)
```
⇒
```
1  10  2.71828
```

HERE IS A LITTLE PROGRAM TO ILLUSTRATE SGN, ABS & INT.

```
10 PRINT "TYPE A SUM OF MONEY; + OR- "
20 INPUT L
30 LET S=INT(ABS(L)*100+.5)/100
40 LET D=INT(S)*SGN(L)
50 LET C=INT((S-ABS(D))*100)
60 PRINT D;"DOLLARS AND";C;"CENTS"
70 END
RUN
TYPE A SUM OF MONEY;+OR-
? -123.456
-123 DOLLARS AND 46 CENTS
```

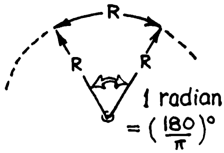
ABS(L) IS POSITIVE WHATEVER THE SIGN OF L; *100 CONVERTS TO CENTS; +.5 ADDS HALF A CENT; INT( ) ROUNDS TO NEAREST CENT; /100 CONVERTS THE FORM TO d.cc FROM THE ORIGINAL ±d.cccc....

D IS THE DOLLARS WITH THE SIGN RESTORED

C IS THE CENTS & IS ALWAYS POSITIVE

TRIG. FUNCTIONS

ALL ANGLES ARE MEASURED IN *RADIANS*.

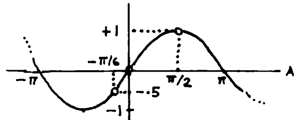


IN THE EXAMPLES BELOW P IS SET EQUAL TO π.

```
70 LET P= 3.141593
```

SIN(A)

"THE SINE OF"



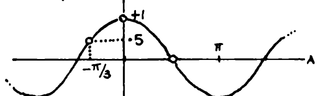

```
80 PRINT SIN(-P/6); SIN(0); SIN(P/2)
```

⇨

```
-.5  0  1
```

COS(A)

"THE COSINE OF"



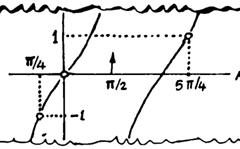

```
90 PRINT COS(-P/3); COS(0); COS(P/2)
```

⇨

```
.5  1  0
```

TAN(A)

"THE TANGENT OF"




```
100 PRINT TAN(-P/4); TAN(0); TAN(5*P/4)
110 PRINT TAN(P/2)
```

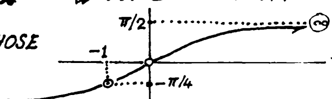
$\tan(\frac{\pi}{2}+n\pi)=\infty$

⇨

```
-1  0  1
ERROR: TANGENT TOO BIG
```

ATN(T)

"THE ANGLE WHOSE TANGENT IS"
(or $\tan^{-1}(T)$)

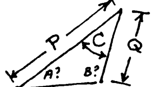



```
120 PRINT ATN(1E38); ATN(0); ATN(-1)
```

⇨

```
1.57080  0  -.78540
```

THE FOLLOWING EXAMPLE PROGRAM USES TRIGONOMETRICAL FUNCTIONS:



GIVEN P, Q & ANGLE C

- *THE AREA IS:* $\frac{1}{2} PQ \sin C$
- *ANGLE A IS:* $\tan^{-1}(Q\sin C/(P-Q\cos C))$
- *ANGLE B IS:* $\tan^{-1}(P\sin C/(Q-P\cos C))$
- *SIDE G IS:* $\sqrt{P^2+Q^2-2PQ\cos C}$

```
10  PRINT "TYPE LENGTHS (P&Q) & INCL. ANGLE (DEG.)"
20  LET K= 3.141593/180
30  INPUT P, Q, D
40  LET C= D*K
50  LET S= 0.5*P*Q*SIN(C)
60  LET A= ATN(Q*SIN(C)/(P-Q*COS(C)))/K
70  LET B= ATN(P*SIN(C)/(Q-P*COS(C)))/K
80  LET G= SQR(P*P+Q*Q-2*P*Q*COS(C))
90  PRINT "AREA";S; "OPPOSITE SIDE";G
100 PRINT "BASE ANGLES"; A ; "AND" ; B
110 END
```

DEGREES TO RADIANS

(RADIANS TO DEGREES)

RND

BASIC CAN "THROW DICE" TO GENERATE RANDOM NUMBERS — *PSEUDO* RANDOM NUMBERS TO BE MORE PRECISE.

```
10  REM   TO ILLUSTRATE  RND
20  LET X = RND
30  LET Y = RND
40  LET Z = RND
50  PRINT  X;Y;Z
60  END
RUN
·240643   ·417191  ·192204
```

RND IS A FUNCTION WITHOUT AN ARGUMENT

THE SAME RESULT EVERY RUN

NOTE: THE ORIGINAL DARTMOUTH BASIC, & SEVERAL EXISTING ONES, REQUIRE AN ARGUMENT:

LET X = RND(A).

SOME BASICS IGNORE THIS ARGUMENT; OTHERS USE IT IN SUBTLE WAYS SUCH AS TO DENOTE DIFFERENT "STREAMS" OF NUMBERS.

IN AN EXPRESSION "RND" MAY BE TREATED IN EXACTLY THE SAME WAY AS A NUMERICAL VARIABLE; WHEREVER YOU MAY TYPE X YOU MAY ALSO TYPE RND. STATEMENTS 20 TO 50 ABOVE COULD BE COMBINED INTO ONE STATEMENT:

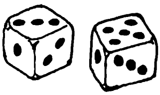
```
20 PRINT  RND; RND; RND
```

WHEN A PROGRAM IS RUNNING, EVERY TIME *BASIC* MEETS "RND" IT SUPPLIES A RANDOM NUMBER, n, WHERE $0 \leq n < 1$ (NB. SOMETIMES 0, NEVER 1). IT IS NOT REALLY RANDOM, IT IS CALLED *PSEUDO RANDOM*. ON MEETING RND THE COMPUTER GENERATES AND PROVIDES THE NEXT IN A FIXED CYCLE OF NUMBERS. *BASICS* DIFFER, BUT ONE CYCLE COMMONLY USED HAS A MILLION SIX-DIGIT FRACTIONS FROM 0.000000 TO 0.999999. IN EVERY CYCLE EACH FRACTION OCCURS EXACTLY ONCE. THE CYCLE STARTS AFRESH IN EVERY RUN; IF A PROGRAM USES ALL THE NUMBERS IN THE CYCLE THEN THE CYCLE BEGINS AGAIN. THE PROGRAM ABOVE WOULD GIVE THE SAME RESULT IN EVERY RUN — BUT A DIFFERENT VERSION OF *BASIC* MIGHT PRODUCE THREE COMPLETELY DIFFERENT NUMBERS. HOWEVER ...

RANDOMIZE

THIS STATEMENT MAKES *BASIC* START THE CYCLE AT AN UNPREDICTABLE PLACE ON EACH ENCOUNTER.

THIS PROGRAM THROWS A PAIR OF DICE:



```
10  RANDOMIZE
20  LET X=INT(1+6*RND)
30  LET Y=INT(1+6*RND)
40  PRINT "THROW:"; X ; "AND";Y
50  END
RUN
THROW: 3 AND 5
```

"RANDOMIZE" ENSURES AN UNPREDICTABLE THROW ON EACH RUN

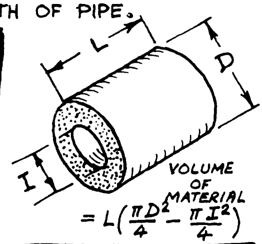
SOME *BASICS* DON'T HAVE RANDOMIZE; INSTEAD THEY USE AN ARGUMENT, RND(A). THE WAY "A" IS USED DIFFERS FUNDAMENTALLY FROM *BASIC* TO *BASIC*; YOU HAVE TO CONSULT THE SPECIFIC MANUAL.

DEF

IN *BASIC* YOU CAN *DEFINE* UP TO 26 OF YOUR OWN FUNCTIONS USING THE **DEF** STATEMENT. THESE FUNCTIONS ARE NAMED FNA, FNB, FNC *etc.*

COMPARE THESE TWO PROGRAMS, BOTH OF WHICH CALCULATE AND PRINT THE VOLUME OF MATERIAL IN A LENGTH OF PIPE.

```
10   PRINT "TYPE: L,D & I"
20   INPUT          L,D,  I
30   LET A1 = 3.141592*D↑2/4
40   LET A2 = 3.141592*I↑2/4
50   LET  V = L*(A1-A2)
60   PRINT "VOLUME IS";V
70   END
```



"DEF" IS SHORT FOR "DEFINE"

```
10   DEF  FNC(X)=3.141592*X↑2/4
20   PRINT "TYPE: L,D & I"
30   INPUT          L,D,  I
40   LET  V=L*(FNC(D)-FNC(I))
50   PRINT "VOLUME IS";V
60   END
```

ONCE YOU HAVE DEFINED A FUNCTION (AS IN LINE 10 ABOVE) YOU MAY USE IT EXACTLY AS THOUGH IT WERE AN *INTRINSIC* FUNCTION.

WHAT HAPPENED TO THE VARIABLE X ? NOTHING: IT IS CALLED A *DUMMY ARGUMENT*. THIS "DEF" STATEMENT SAYS: "COMPUTE THE VALUE OF WHAT LIES IN BRACKETS; SQUARE IT; MULTIPLY THE SQUARE BY 3.141592; DIVIDE THIS PRODUCT BY 4 AND GIVE THE RESULT TO FNC( )". IT WOULD BE JUST AS LOGICAL TO WRITE:

```
10 DEF FNC( )=3.141592* ↑2/4
```

BUT THERE IS NO SUCH CHARACTER AS ON THE KEYBOARD SO *BASIC* INSISTS ON THE NAME OF A VARIABLE TO BE USED AS A DUMMY. THE VARIABLE X IS USED ABOVE BUT *BASIC* WILL NOT CHANGE THE VALUE OF X AT STATEMENT 40.

UNFORTUNATELY THERE ARE *BASICS* THAT *WOULD* CHANGE THE VALUE OF X AT STATEMENT 40 ABOVE. YOU CAN TEST YOUR VERSION BY RUNNING THE FOLLOWING PROGRAM.

```
10   REM   TEST FOR DUMMY DUMMIES
20   DEF FNA(T)=T+2
30   LET T=0
40   LET A=FNA(3)
50   PRINT T;"SHOULD STAY ZERO"
60   END
```

IF YOUR VERSION PRINTS A 5 THEN YOU WILL HAVE TO KEEP VARIABLES DISTINCT FROM ARGUMENTS: SEE OPPOSITE

YOU MAY ALSO DEFINE FUNCTIONS *WITHOUT* ARGUMENTS SEE OPPOSITE.

HERE ARE SOME EXAMPLES OF FUNCTIONS DEFINED:

```
10  REM  FUNCTIONS WITH NO ARGUMENT
20  DEF FNI = INT(2+11*RND)            RANDOM INTEGER IN THE RANGE 2 TO 12
30  DEF FNR = 3.141592/180            MULTIPLY DEGREES BY FNR TO GET RADIANS
40  REM                               AREA OF A CIRCLE OF DIAMETER "DUMMY X"
50  REM  FUNCTIONS WITH DUMMY ARGUMENT
60  DEF FNC(X) = 3.141592*X*X/4       "MACAULAY" OR "DIRAC" FUNCTION OF X
70  DEF FNM(X) = X * SGN(1+SGN(X))    =X IF X≥0
                                      =0 IF X<0
```

YOU MAY ALSO HAVE "ARGUMENTS" THAT ARE ~~NO~~ NOT DUMMIES; THE FUNCTION USES VALUES OF VARIABLES IN YOUR PROGRAM.

```
80  REM  FUNCTIONS USING PROGRAM VARIABLES
90  DEF FNH = SQR(A*A+B*B)             HYPOTENUSE OF RIGHT ANGLED TRIANGLE WITH NORMAL SIDES A&B
100 DEF FNA(X)= 0.5*A*B*SIN(X)         AREA OF A TRIANGLE WITH SIDES A&B AND INCLUDED ANGLE "DUMMY X"
110 DEF FNL = P-INT(P/Q)*Q             FNL IS THE REMAINDER WHEN P IS DIVIDED BY Q
120 DEF FNT(X) = INT(X*10↑D+.5)/10↑D   ROUND "DUMMY X" TO D DECIMAL PLACES
130 DEF FNG = INT(A+(B-1)*RND)         FNG IS A RANDOM INTEGER IN THE RANGE A TO B
```

BASICS DIFFER. IF YOU WANT TO WRITE "PORTABLE" PROGRAMS OBSERVE THE FOLLOWING RULES:

★ MAKE SURE THE DEF STATEMENT IS ON A LOWER-NUMBERED LINE THAN THE FIRST USAGE OF THE FUNCTION.

★ MAKE SURE YOUR PROGRAM *OBEYS* THE DEF STATEMENT ONCE. (DON'T JUMP ROUND IT WITH "GOTO" ⇒ SEE P.40.)

★ EVEN IF YOUR VERSION ALLOWS IT, DON'T HAVE MORE THAN ONE DUMMY ARGUMENT. *e.g.* DON'T HAVE `DEF FNA(A,B,C)=A+B+C`

★ DON'T MAKE FUNCTIONS MORE THAN ONE LINE LONG. SOME *BASICS* ALLOW THIS; YOU SIGNIFY THE END OF A MULTI-LINE DEFINITION WITH THE STATEMENT "FNEND".

★ ALWAYS PUT A DUMMY ARGUMENT EVEN IF NOT USED. *e.g.* WRITE LINE 30 ABOVE AS DEF FNR(0)= 3.141592/180. SOME *BASICS* DON'T ALLOW FUNCTIONS WITHOUT AN ARGUMENT.

★ FOR SAFETY USE LETTER O (ALSO O1, O2, *etc.*) EXCLUSIVELY AS DUMMY ARGUMENTS ⇒ NEVER AS VARIABLES! SOME *BASICS* DO NOT TREAT ARGUMENTS AS TRUE DUMMIES. (SEE OPPOSITE FOR THIS TEST.)

PRINT

THIS IS THE MOST VERSATILE STATEMENT IN *BASIC* AND ALSO ONE WHICH DIFFERS MUCH IN INTERPRETATION FROM ONE *BASIC* TO ANOTHER.

THE FOLLOWING PROGRAM PRINTS THE SQUARE OF ANY NUMBER:

```
10  LET  E$ = "EQUALS"
20  PRINT "TYPE A NUMBER"
30  INPUT  A
40  PRINT  "THE SQUARE OF"; A ; E$ ; A*A
50  END
RUN
TYPE  A  NUMBER
?   4
THE  SQUARE  OF  4  EQUALS  16
```

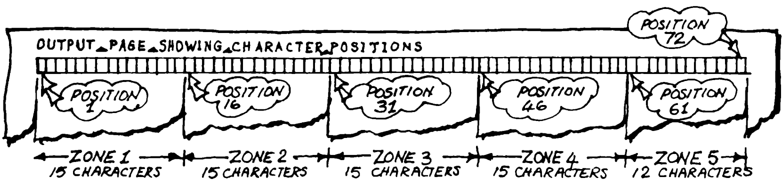
NUMERICAL VARIABLE
EXPRESSION
TEXT OF ANY LENGTH
TEXTUAL VARIABLE

LINE 40 SHOWS EXAMPLES OF FOUR OF THE POSSIBLE THINGS THAT CAN BE PUT IN THE LIST FOLLOWING THE WORD PRINT:

- ★ "THE SQUARE OF": A TEXT (ANY LENGTH THAT WILL FIT THE LINE) WHICH GETS PRINTED EXACTLY AS TYPED BUT WITHOUT THE QUOTATION MARKS.
- ★ A: A NUMERICAL VARIABLE WHOSE *VALUE* GETS PRINTED — NOT ITS NAME.
- ★ E$: A TEXTUAL VARIABLE WHOSE *TEXT* GETS PRINTED.
- ★ A*A: AN EXPRESSION WHOSE *VALUE* GETS PRINTED.

A PRINT STATEMENT MAY HAVE ANY MIXTURE OF TEXTS, VARIABLES AND EXPRESSIONS AS LONG AS THE LIST WILL FIT THE LINE. THEY ARE SEPARATED FROM ONE ANOTHER BY *SEMICOLONS* (AS ABOVE) OR BY *COMMAS* WHICH CAUSE *BASIC* TO PRINT ITEMS IN *ZONES* AS DESCRIBED BELOW.

THE PICTURE BELOW SHOWS A PAGE WITH 72 POSITIONS ACROSS IT. *BASIC* DIVIDES THE PAGE INTO 4 ZONES, EACH OF 15 CHARACTER POSITIONS, AND ONE ZONE OF 12. (*BASICS* DIFFER GREATLY HERE BOTH IN WIDTH OF PAGE AND IN WIDTH OF ZONE, BUT THE CONCEPT IS UNIVERSAL.) THE CHARACTER POSITIONS ARE NUMBERED FROM 1, AS DONE BY SOME *BASICS*, BUT MANY *BASICS* NUMBER FROM ZERO (*i.e.* 0 TO 71 INSTEAD OF 1 TO 72).



```
1 PRINT  A; B, C
```

A *SEMICOLON* TELLS THE PRINTING HEAD *NOT TO MOVE* BEFORE PRINTING THE NUMBER OR TEXT SIGNIFIED (IN THIS CASE THE VALUE OF B). IF THERE ISN'T ENOUGH ROOM ON THE LINE THEN THE PRINTING HEAD RETURNS TO START A NEW LINE.

```
2 PRINT  A; B , C
```

A *COMMA* TELLS THE PRINTING HEAD TO MOVE TO THE FIRST POSITION IN THE NEXT AVAILABLE ZONE BEFORE PRINTING THE NUMBER OR TEXT SIGNIFIED (IN THIS CASE THE VALUE OF C). IF THE PRINTING HEAD IS ALREADY SOMEWHERE IN ZONE 5 THEN THE NEXT AVAILABLE ZONE IS ZONE 1 ON THE FOLLOWING LINE.

```
3 PRINT A; B,
4 PRINT C, D
```

THEN WHAT ABOUT THE *FIRST* ITEM IN A LIST (SUCH AS C)? NO EXCEPTION: *BASIC* ACTS ON THE COMMA OR SEMICOLON AT THE END OF THE *PREVIOUS* LIST, EXACTLY AS THOUGH YOU HAD TYPED (IN THIS CASE):

```
3 PRINT  A; B ,C, D
```

```
5 PRINT  E; F
6 PRINT  G, H
```

WHAT IF THERE IS *NO* COMMA OR SEMICOLON AT THE END OF THE PREVIOUS LIST, OR NO PREVIOUS LIST AT ALL? ANSWER: AFTER OBEYING A PRINT STATEMENT HAVING NO COMMA OR SEMICOLON AT THE END OF ITS LIST THE PRINTING HEAD RETURNS TO START A NEW LINE. YOU MAY ALSO ASSUME THIS HAPPENS BEFORE *BASIC* OBEYS THE VERY FIRST PRINT STATEMENT.

```
7 PRINT
```

WHAT IF THERE IS AN *EMPTY* LIST? THEN *BASIC* PRINTS NOTHING ON THE LINE, AND BECAUSE THERE IS NO COMMA OR SEMICOLON THE PRINTING HEAD RETURNS TO START A NEW LINE AS DESCRIBED ABOVE. IN SHORT: *THIS IS THE WAY TO MAKE BASIC PRINT A BLANK LINE.*

```
8 PRINT  I "SQD=" I*I
```

SOME *BASICS* ALLOW YOU TO LEAVE OUT THE PUNCTUATION ON EITHER SIDE OF A TEXT, ASSUMING EITHER A COMMA OR SEMICOLON DEPENDING ON THE PARTICULAR VERSION. DON'T DO IT.

HERE IS AN EXAMPLE SHOWING THE USE OF COMMAS & SEMICOLONS.

```
10  DATA     "DAYS", 28, 30, 31
20  READ      T$,    A , B, C
30  PRINT    "JAN", "FEB", "MAR", "APR"
40  PRINT    , "(29 IN LEAP YEARS)"
50  PRINT    C; T$, A; T$, C; T$, B; T$
60  END
RUN
JAN             FEB             MAR             APR
                (29 IN LEAP YEARS)
 31 DAYS         28 DAYS         31 DAYS         30 DAYS
```

NOTE THE COMMA AT THE START OF THE LIST, CAUSING A "SKIP" TO THE SECOND ZONE.

PRINT (CONTINUED)

WHY DOES *BASIC* PRINT

THE SQUARE OF 4 EQUALS 16

AND NOT "THE SQUARE OF 4.00000 EQUALS 16.0000" (REMEMBERING *BASIC* DOES ARITHMETIC TO AT LEAST 6 FIGURES) ?

THE ANSWER IS THAT *BASIC* ASSUMES YOU ARE NOT INTERESTED IN "TRAILING ZEROS". *BASIC* TAKES OTHER DECISIONS ABOUT THE WIDTH AND STYLE OF PRINTED NUMBERS AS EXPLAINED BELOW.

IF A NUMBER CAN BE ACCURATELY EXPRESSED AS AN INTEGER OF SIX DIGITS OR LESS THEN *BASIC* PRINTS IT AS AN *INTEGER*.

```
10 LET  A = 654321
20 PRINT   A ; -A
30 PRINT   0.00;  20.0 ; 20.00002
```

SEE THE KEY BELOW FOR ▼ & ▲

```
▼654321▲-654321
▼0▲▼20▲▼20
```

IF A NUMBER IS SMALLER (NEARER TO ZERO) THAN 0.1 *BASIC* PRINTS IT IN *E-FORM*. MOST *BASICS* PRINT ONE DIGIT BEFORE THE DECIMAL POINT AND FIVE AFTER, BUT SOME PRINT ALL SIX DIGITS AFTER THE POINT. THEN MOST *BASICS* PRINT AN E FOLLOWED BY A PLUS OR MINUS SIGN FOLLOWED BY TWO DIGITS FOR THE EXPONENT.

```
40 PRINT  A/10↑7 ;   -A / 10↑9
50 PRINT  0.060 ;   -0.0006
```

```
▼6·54321E-03▲-6·54321E-04▲
▼6·00000E+02▲-6·00000E-04▲
```

BASIC ALSO PRINTS BIG NUMBERS (10^6 AND BIGGER) IN *E-FORM*.

```
60 PRINT   100*A ;
70 PRINT   -1000000000*A
```

```
▼6·54321E+07▲-6·54321E+13▲
```

BASIC PRINTS NUMBERS BETWEEN 0.1 AND 10^6 IN *DECIMAL FORM*.

```
80 PRINT   A/10 ;  -A/100
90 PRINT   -A/1000  ; A/1000000
```

```
▼65432·1▲-6543·21▲
-654·321▲▼·654321▲
```

THIS IS WHAT *BASIC* DOES WHEN PRINTING A NUMBER:

- ▼ PRINTS A MINUS SIGN IF THE NUMBER IS NEGATIVE, OTHERWISE A SPACE;
- # THEN PRINTS AN *INTEGER* OR AN *E-FORM* OR A *DECIMAL NUMBER* DEPENDING ON SIZE AND PRECISION AS EXPLAINED ABOVE;
- ▲ THEN PRINTS ONE TRAILING SPACE.

SOME *BASICS* THEN ADD *TWO* OR *ONE* OR *NO* FURTHER TRAILING SPACES TO MAKE THE TOTAL NUMBER OF PRINTED CHARACTERS A MULTIPLE OF *THREE*: OTHERS ALWAYS PRINT TWO TRAILING SPACES.

MOST *BASICS* PRINT *TEXTS* AND *TEXTUAL VARIABLES* WITHOUT ADDING TRAILING SPACES AND WITHOUT STRIPPING TRAILING SPACES FROM THE TEXTS THEMSELVES.

```
100 DATA  "CATCH" , "DALMATIANS"   "STEPS"
110 READ     C$   ,      D$          S$
120 DATA   22.00  ,    1.01E2        39
130 READ     C    ,      D           S
140 PRINT C$; C   ,    D; D$         S; S$
150 PRINT
160 PRINT C$; -C  ,    S; S$         -D; D$
170 END
RUN
```

OUTPUT FROM LINE 140 ON

```
CATCH▼22▲    ▼101▲DALMATIANS▼39▲STEPS
                                          BLANK LINE
CATCH-22▲    ▼39▲STEPS    -101▲DALMATIANS
```

|←ZONE 1→|←ZONE 2→|←ZONE 3→|←ZONE 4→|←ZONE 5→|

TYPE AND RUN THE PROGRAM ABOVE (FROM LINE 10 TO LINE 170) TO SEE IF YOUR VERSION OF *BASIC* BEHAVES DIFFERENTLY. FROM VERSIONS THAT MAKE THE LENGTH OF EVERY NUMBER A MULTIPLE OF THREE CHARACTER POSITIONS THE OUTPUT WOULD BE:

```
CATCH▼22▲△△    ▼101▲△DALMATIANS            ▼39▲△△STEPS

CATCH-22▲△△    ▼39▲△△STEPS    -101▲△DALMATIANS
```

TAB( );

MOST *BASICS* HAVE THE TAB FUNCTION WHICH MAY BE USED WITH **PRINT**.

TO VARY THE LAYOUT OF RESULTS *UNDER CONTROL OF A PROGRAM* YOU MAY PUT TAB FUNCTIONS IN THE LIST THAT FOLLOWS THE WORD PRINT.

```
10  PRINT "GIVE ME A VALUE FOR A"
20  INPUT A
30  PRINT TAB(A); "MAN"; TAB(2*A); "EATING"; TAB(3*A+5);"FISH"
40  END
RUN
GIVE ME A VALUE FOR A
? 3
  MANEATING  FISH
RUN
GIVE ME A VALUE FOR A
? 5
    MAN  EATING    FISH
```

POSITION 5 | POSITION 2×5 = 10 | POSITION 3×5 +5=20

A TAB FUNCTION ONLY MAKES SENSE AS AN ITEM IN A LIST AFTER THE WORD PRINT. YOU MAY PUT A VARIABLE OR EXPRESSION INSIDE THE BRACKETS; *BASIC* WORKS OUT ITS VALUE AND MOVES THE PRINTING HEAD TO THE CHARACTER POSITION GIVEN BY THE RESULT. THERE ARE SOME TRICKY POINTS TO WATCH WHEN USING TAB:

★ SOME *BASICS* NUMBER CHARACTER POSITIONS FROM 1 (PAGE 28) BUT MANY *BASICS* NUMBER THEM FROM ZERO. YOU CAN MAKE PROGRAMS "PORTABLE" BY ALWAYS NUMBERING FROM 1 AND NEVER USING POSITIONS GREATER THAN 71.

★ SOME *BASICS* USE THE *NEAREST* INTEGER TO THE RESULT OF THE EXPRESSION WHEREAS MANY *BASICS* TAKE THE *INTEGRAL PART*. IF YOUR FUNCTION COULD YIELD A NON-INTEGRAL RESULT USE INT TO *ENSURE* THE RESULT YOU INTEND. *e.g.*

```
; TAB( INT (P/3 + .5) );
```

★ SOME *BASICS* DISREGARD THE PUNCTUATION MARK FOLLOWING A TAB( ) *e.g.* TAB(6); IS TREATED THE SAME WAY AS TAB(6), BUT OTHERS TREAT A COMMA AFTER TAB AS AN ERROR; YET OTHERS ACT ON SUCH A COMMA BY MOVING THE PRINTING HEAD TO THE NEXT ZONE. SO ALWAYS USE SEMICOLONS AFTER TAB( );.

★ IF THE PRINTING HEAD HAS ALREADY PASSED THE POSITION EVALUATED BY THE APPROPRIATE TAB FUNCTION — OR IF THE EVALUATED POSITION IS OFF THE PAGE — DIFFERENT *BASICS* TAKE DIFFERENT ACTIONS USUALLY RESULTING IN MESSY OUTPUT. DON'T RELY ON SPECIFIC INTERPRETATIONS; GET THE EXPRESSIONS RIGHT.

★ TAB( ) MUST STAND ALONE AS AN ITEM IN THE LIST; IT MAY NOT BE COMBINED IN AN EXPRESSION HOWEVER SIMPLE THE EXPRESSION:

```
100 PRINT    4*TAB(A*6); X
```

TAB() IS USEFUL FOR PLOTTING CRUDE GRAPHS ON THE OUTPUT PAGE. FOR AN EXAMPLE OF THIS WE HAVE TO ANTICIPATE PAGE 48 WHICH EXPLAINS WHY STATEMENT 30 BELOW LETS X TAKE SUCCESSIVE VALUES OF 0, 15, 30 *etc. to* 180.

```
10 PRINT "THE GRAPH OF COSINE(X) FOR X = 0 TO 180";
15 PRINT " IN STEPS OF 15 DEGREES"
20 PRINT " X"; TAB(62);"COS(X)"
30 FOR X = 0 TO 180 STEP 15
40 LET C = COS(X * 3.141592 / 180)
50 LET P = INT(30 * ABS(C)+.5) * SGN(C)
60 PRINT X; TAB(P + 36); "*"
70 NEXT X
80 END
```

CONVERT TO RADIANS & GET COSINE IN C

COS(0) IS SCALED TO 30 PRINT POSITIONS & ROUNDED TO THE NEAREST POSITION

VERTICAL AXIS IS OFFSET 36 POSITIONS TO MIDDLE OF PAGE

```
RUN

THE GRAPH OF COSINE(X) FOR X = 0 TO 180 IN STEPS OF 15 DEGREES
 X                                                            COS(X)
 0                                                                  *
 15                                                                *
 30                                                             *
 45                                                         *
 60                                                     *
 75                                                *
 90                                          *
 105                                   *
 120                             *
 135                        *
 150                   *
 165                *
 180 *
```

PRINT USING

NOT EVERY *BASIC* HAS THIS STATEMENT; DETAILED RULES VARY AMONG THOSE THAT DO. IT IS A DEVICE FOR BUILDING *IMAGES* OF THE DESIRED OUTPUT.

```
10 LET G=1000.00
20 PRINT USING 30 ,G,G/20
30:####GUILDERS! COME, TAKE ##!
40 END
RUN
1000 GUILDERS! COME, TAKE 50!
```

LINE NUMBER OF "IMAGE" TO BE USED

LIST STARTING WITH A COMMA

COLON: FOLLOWED BY AN "IMAGE"

ONE BASIC USES % NOT :

"MOULD" FOR G

"MOULD" FOR G/20

THE PRINT USING STATEMENT POINTS TO ANOTHER LINE OF THE PROGRAM HOLDING AN *IMAGE* OF WHAT IS TO BE PRINTED. THIS IMAGE MAY CONTAIN *MOULDS* (USUALLY CALLED *FORMATS*). EACH MOULD DETERMINES THE PLACE AND SHAPE OF ITS CORRESPONDING ITEM IN THE PRINT LIST WHEN PRINTED.

AFTER THE WORDS "PRINT USING" TYPE THE NUMBER OF THE LINE OF PROGRAM WHERE THE IMAGE IS TO BE FOUND. (THIS MAY BE ANYWHERE IN THE PROGRAM AND SEVERAL PRINT STATEMENTS MAY USE IT.) THEN TYPE A *COMMA*† WHICH STARTS A LIST OF VARIABLES OR EXPRESSIONS SEPARATED BY *COMMAS*. DON'T TYPE A COMMA AT THE END OF THE LIST; THE PRINTING HEAD RETURNS AUTOMATICALLY TO START A NEW LINE WHEN A PRINT USING STATEMENT HAS BEEN OBEYED. (CONVERSELY THE PRINTING HEAD *DOESN'T* START A NEW LINE *BEFORE* SUCH A STATEMENT IS OBEYED; IT STAYS WHERE IT WAS LEFT BY THE PREVIOUS "PRINT" OR "PRINT USING".)

FOR THE *IMAGE* LINE: TYPE A *COLON* AFTER THE LINE NUMBER. THEN TYPE EXACTLY WHAT YOU WANT THE COMPUTER TO PRINT BUT REPRESENT EACH *DIGIT* BY # IN ORDER TO FIX A *MOULD* FOR THE SHAPE OF THE PRINTED NUMBER. IF YOU WANT A DECIMAL POINT PRINTED THEN PUT A DECIMAL POINT INSIDE THE MOULD.

```
10:FL####.##! COME, TAKE FL###.##!
20 PRINT USING 10 , 1000,50
30 END
RUN
FL 1000.00! COME, TAKE FL 50.00!
```

SEE FOOTNOTE

FL IS THE CURRENCY SIGN FOR GUILDERS

† N.C.C. "STANDARD BASIC" SAYS A COLON: IT WOULD BE MUCH NICER THAN A COMMA BUT I HAVE STILL TO FIND A *BASIC* THAT ALLOWS A COLON.

IF THE PROGRAM COMPUTES NUMBERS TOO BIG TO FIT THEIR MOULDS THEN *BASIC* OBJECTS ; SOME *BASICS* BY FILLING THE MOULD WITH ASTERISKS, SOME BY CHANGING OR EXTENDING THE MOULD, SOME BY STOPPING EXECUTION ALTOGETHER.

###.## 999.99 -99.99	THIS MOULD CAN COPE WITH POSITIVE NUMBERS AS BIG AS 999.99 AND NEGATIVE NUMBERS AS BIG AS -99.99

NO HARM IS DONE BY MAKING THE MOULDS LONGER THAN STRICTLY NECESSARY.

```
5:INTEGRAL ##   DECIMAL ###.##
10  LET A= 9.999
15  PRINT USING 5      ,A,A
20  END
RUN
INTEGRAL 9  DECIMAL 10.00
```

INTEGRAL PART OF 9.999

9.999 "ROUNDED" TO TWO DECIMALS

BASIC FILLS INTEGER MOULDS FROM RIGHT TO LEFT: ####

BASIC FILLS DECIMAL MOULDS FROM THE POINT OUTWARDS: ###.##

BASIC PUTS THE *INTEGRAL PART* OF A NUMBER INTO AN INTEGER MOULD. *BASIC* *"ROUNDS"* A NUMBER DESTINED FOR A DECIMAL MOULD TO THE NUMBER OF PLACES SIGNIFIED.

IF THE PRINT LIST OFFERS MORE ITEMS THAN THE IMAGE CAN DIGEST THEN *BASIC* USES THE IMAGE AGAIN AND AGAIN UNTIL THE LIST IS CONSUMED.

```
10   :## BARLEY LOAVES & ## SMALL FISHES
20   PRINT USING 10     ,5,2,10,4,20
30   END
RUN
 5 BARLEY LOAVES &  2 SMALL FISHES
10 BARLEY LOAVES &  4 SMALL FISHES
20 BARLEY LOAVES &
```

THIS EXAMPLE ALSO SHOWS WHAT HAPPENS WHEN THE LIST OFFERS *TOO FEW* ITEMS FOR THE IMAGE. PRINTING STOPS AT THE FIRST FRUSTRATED MOULD.

SO FAR

THE RULES ARE THE SAME FOR NEARLY ALL VERSIONS OF *BASIC* THAT OFFER PRINT USING.

(AT LEAST ONE, HOWEVER, DEMANDS THE FORMS SHOWN HERE: THESE ARE *OPTIONAL* FACILITIES IN SEVERAL *BASICS*).

```
100 LET A$="ANS=##.#"
110 PRINT USING A$ ,X
```

```
100 PRINT USING "ANS=##.#",X
```

THE FACILITIES & RULES OVERLEAF ARE MORE VARIABLE FROM ONE *BASIC* TO ANOTHER THAN THOSE EXPLAINED SO FAR: FOR THE SAKE OF "PORTABILITY" IT WOULD BE BEST TO AVOID THOSE OVERLEAF.

PRINT USING (CONTINUED)

YOU CAN MAKE MOULDS FOR PRINTING NUMBERS IN *E-FORM* BY ADDING UP-ARROWS TO A DECIMAL MOULD. FOR ANY ONE VERSION OF *BASIC* THE NUMBER OF ARROWS IS FIXED: IN SOME FOUR; IN OTHERS FIVE (AND SOME *BASICS* USE AN EXCLAMATION MARK IN PLACE OF AN ARROW).

-34.5600 ⇒ #.### ↑↑↑↑ ⇒ -.340E+02.

THERE MUST BE AT LEAST ONE # BEFORE THE DECIMAL POINT TO RESERVE A POSITION FOR THE SIGN.

```
10:***A TITLE***
20:
30 PRINT USING 10
40 PRINT USING 20
50 END

RUN

***A TITLE***
```

BLANK LINE BY USING 20

IN SOME *BASICS* YOU MAY HAVE AN EMPTY PRINT LIST — EVEN AN EMPTY IMAGE. (THESE THINGS ARE MORE EASILY DONE BY PRINT WITHOUT THE USING.)

SOME *BASICS* ALLOW CURRENCY SIGNS IN THE MOULD.

1.234				$1.23
23.456	⇒	$$$$.##	⇒	$23.46
345.678				$345.68

THE CURRENCY SIGN (POSSIBLY £ IN THE U.K.) "FLOATS" TO THE LEFT. SOME *BASICS* PERFORM THE SAME TRICK WITH ASTERISKS.

SOME *BASICS* ALLOW† A PLUS OR MINUS SIGN IN FRONT OF THE MOULD *e.g.* +##.# AND -#.##

\+ SAYS "PRINT A PLUS SIGN IN FRONT OF THE NUMBER IF IT IS POSITIVE; A MINUS SIGN IF NEGATIVE"

\- SAYS "PRINT A *SPACE* IN FRONT OF THE NUMBER IF IT IS POSITIVE; A MINUS SIGN IF NEGATIVE"

IT IS NOT ALWAYS CLEAR FROM THE MANUALS WHETHER THIS FACILITY CAN BE USED IN CONJUNCTION WITH THE CURRENCY SIGN.

† *N.C.C. "STANDARD BASIC" REQUIRES A SIGN IN FRONT OF THE MOULD.*

IN MOST *BASICS* OFFERING PRINT USING IT IS POSSIBLE TO MAKE MOULDS FOR *TEXTUAL* VARIABLES. THESE ARE EXTREMELY USEFUL BUT UNFORTUNATELY THEIR DETAILS DIFFER.

```
10   REM     COMMON START
20   LET   T$= "TO"
30   LET   B$= "BE"
40   PRINT USING 50  ,T$,B$,T$,B$
```

SEE FOUR DIFFERENT LINES 50 BELOW

```
60   REM     COMMON ENDING
70   END

RUN
```

DIFFERENT LINES 50 FOR DIFFERENT VERSIONS OF *BASIC* ARE ILLUSTRATED BELOW. THE RESULT PRODUCED BY USING EACH IMAGE IS SHOWN IMMEDIATELY BELOW THAT IMAGE.

```
50: ##   ### OR NOT #.#   #
      TO  BE    OR NOT TO    B
```

FILLED FROM LEFT TO RIGHT

DECIMAL POINT (AND ↑) ACT THE SAME WAY AS #

TRUNCATION TO THE RIGHT IF TEXT IS TOO LONG FOR MOULD

```
50: 'LL  'RRR OR NOT  'CCC    '
     TO     BE OR NOT   TO    B
```

APOSTROPHE DENOTES TEXTUAL MOULD

L's SAY JUSTIFY LEFT

R's SAY JUSTIFY RIGHT

C's SAY CENTRALIZE

```
50:\\     \\    OR NOT   \   \   !
    TO     BE   OR NOT   TO      B
```

! FOR SINGLE CHARACTER

SPACES BETWEEN \ AND \ ARE SIGNIFICANT & THE MOULD IS FILLED FROM LEFT TO RIGHT

```
50: <#    <#   OR NOT  >####    >
     TO    BE  OR NOT     TO    B
```

THIS ONE IS N.C.C. "STANDARD BASIC".

< SAYS JUSTIFY LEFT & TRUNCATE TO THE RIGHT

> SAYS JUSTIFY RIGHT & TRUNCATE TO THE LEFT

SINGLE CHARACTER MOULD — ALSO <

THERE MAY BE MORE WAYS YET. WHY CAN'T WE STANDARDIZE? EVEN BAD STANDARDS WOULD BE BETTER THAN NONE AT ALL.

3

CONTROL

GO TO

WITH THIS INSTRUCTION YOU MAY ALTER THE SEQUENCE IN WHICH *BASIC* OBEYS THE NUMBERED STATEMENTS OF YOUR PROGRAM.

THIS PROGRAM NEVER REACHES ITS END. ON BEING GIVEN A VALUE FOR D IT COMPUTES & PRINTS V, THEN GOES BACK TO LINE 20 TO ASK FOR ANOTHER VALUE FOR D AND SO ON AND SO ON.

THE WAY TO STOP THIS PROGRAM IS TO PRESS THE BREAK KEY (OR WHATEVER KEY YOUR OWN INSTALLATION USES FOR THIS).

```
10 PRINT  "VOLUMES OF BALLS"
20 PRINT
30 PRINT  "TYPE A DIAMETER"
40 INPUT  D
50 LET    V = 3.141592 * D↑3 /6
60 PRINT  "VOLUME OF BALL IS"; V
70 GO TO  20
80 END

RUN

VOLUMES OF BALLS

TYPE A DIAMETER
?  6.5
VOLUME OF BALL IS  143.793

TYPE A DIAMETER
?
```

THIS IS NOT A TRIVIAL EXAMPLE. *BASIC* IS VERY USEFUL AS A CALCULATOR FOR EVALUATING FORMULAE FOR SUCCESSIVE VALUES OF VARIABLES TYPED IN, AND THERE IS NO EASIER WAY OF STOPPING THAN PRESSING A SINGLE KEY.

SYNTAX:

```
70   GO TO   20
```

YOU MAY TYPE GOTO AS ONE WORD

ONLY LINE NUMBERS HERE: YOU CAN'T HAVE LET L= 20 AND SUBSEQUENTLY GO TO L

YOU MAY GOTO ANY LINE IN THE PROGRAM (EVEN IF IT CONTAINS A NON-EXECUTABLE STATEMENT LIKE REM) AND EXECUTION WILL CONTINUE FROM THERE. IF GO TO POINTS TO A NON-EXISTENT LINE NUMBER THEN MOST *BASICS* WILL REFUSE TO START EXECUTION WHEN YOU TYPE RUN (SIMILARLY FOR IF & ON).

IF - THEN

WITH THIS INSTRUCTION YOU MAY ALTER THE ORDINARY SEQUENCE OF EXECUTION BUT ALTER IT *CONDITIONALLY*.

THE LINE HAS TO EXIST

```
20 IF A=B*C THEN 60
```

ONE OF THE SIX POSSIBLE CONDITIONS

GO TO THIS LINE (AND CONTINUE FROM THERE) IF THE CONDITION APPLIES: OTHERWISE JUST CARRY ON

> =

DON'T TYPE A SPACE BETWEEN SYMBOLS IN A CONDITION

LINE NUMBERS ONLY: YOU CAN'T HAVE "THEN L"

THE CONDITIONS ARE:

=	EQUALS
>	IS GREATER THAN
<	IS LESS THAN
>=	IS GREATER THAN OR EQUAL TO
<=	IS LESS THAN OR EQUAL TO
<>	DOES NOT EQUAL

THE THING ON EITHER SIDE OF THE "CONDITION" MAY BE A *NUMBER* OR *EXPRESSION*:

```
30 IF 1+SQR(A↑2+B↑2) > 0.2 THEN 10
40 IF     ABS(A-B)   <= 0.01 THEN 15
```

THE WAY TO TEST "APPROXIMATE" EQUALITY OF A&B

OR IT MAY BE A *TEXT* OR A *TEXTUAL VARIABLE* WHEN THE CONDITION IS NO MORE COMPLICATED THAN *EQUALS* OR *DOES NOT EQUAL* (BUT SEE BOTTOM OF PAGE):

```
50 IF Q$="YES" THEN 150
60 IF "FINISH" <> A$ THEN 10
70 IF R$=T$ THEN 230
```

NOTE: THE TEXTS "YES " AND " YES" ARE NOT EQUAL

IT IS NONSENSE TO COMPARE NUMERICAL VARIABLES WITH TEXTUAL VARIABLES:

```
80 IF Q$ =Y THEN 99
```

MANY *BASICS* ALLOW THE WORDS "GO TO" (OR THE WORD "GOTO") IN PLACE OF "THEN" BUT FOR THE SAKE OF PORTABILITY IT IS BEST TO STICK TO "THEN".

MOST *BASICS* ALLOW MORE COMPLICATED COMPARISONS OF TEXTS. GENERALLY "Z" IS CONSIDERED "GREATER" THAN "A" AND "9" IS GREATER THAN "0". A SPACE " " IS LESS THAN ANY LETTER OR DIGIT. THUS YOU MAY SORT NAMES ALPHABETICALLY:

"A" < "ABALONE" < "ACORN"   &   "V2" < "V8"

STOP

YOU MAY CAUSE *BASIC* TO STOP EXECUTION AT ANY LINE OF YOUR PROGRAM USING THIS INSTRUCTION.

THE *LAST* INSTRUCTION OF EVERY PROGRAM MUST BE "END". NO OTHER STATEMENT BUT THE LAST MAY SAY "END".

"END" SERVES IN A DUAL ROLE:

- IT MARKS THE END OF EVERY PROGRAM FOR THE CONVENIENCE OF THE *BASIC* SYSTEM WHEN TRANSLATING *BASIC* LANGUAGE INTO SOME OTHER COMPUTER CODE STRAIGHT AFTER YOU TYPE "RUN":
- WHEN "END" IS ACTUALLY *"OBEYED"* DURING SUBSEQUENT EXECUTION IT MAKES THE COMPUTER *STOP* EXECUTING THE PROGRAM.

HOWEVER THERE MIGHT BE SEVERAL PLACES IN A PROGRAM WHERE YOU WOULD LIKE TO TELL *BASIC* TO STOP EXECUTION. YOU CAN DO THIS BY A "GO TO" WHICH SENDS CONTROL TO "END" OR YOU CAN DO IT BY A "STOP" INSTRUCTION. "STOP", UNLIKE "END", MAY APPEAR MANY TIMES AND ANYWHERE INSIDE A PROGRAM.

```
10  PRINT "DO YOU LIKE PROGRAMMING ? "
20  INPUT  A$
30  IF  A$ = "NO"  THEN  70
40  IF  A$ = "YES"  THEN  90
50  PRINT "NOT AN UNEQUIVOCAL  ANSWER"
60  GO TO  100
70  PRINT "PERSEVERE!  YOU WILL LEARN TO"
80  GO TO  100
90  PRINT  "FASCINATING  ISN'T  IT ? "
100  END
```

THESE TWO SILLY PROGRAMS DO THE SAME JOB AND ILLUSTRATE THE USE OF "END" AND "STOP".

```
10 PRINT "DO YOU LIKE PROGRAMMING ?"
20 INPUT  A$
30 IF A$ = "NO"  THEN  70
40 IF  A$ = "YES"  THEN  90
50 PRINT  "NOT AN UNEQUIVOCAL ANSWER"
60 STOP
70 PRINT "PERSEVERE!  YOU WILL LEARN TO "
80 STOP
90 PRINT "FASCINATING  ISN'T  IT ?"
100 END
```

EXAMPLE ILLUSTRATING GO TO, IF⇔THEN & STOP

THIS PROGRAM SOLVES A PAIR OF SIMULTANEOUS EQUATIONS HAVING ANY NUMBER OF RIGHT-HAND SIDES. LET THE TWO EQUATIONS BE:

$$aX + bY = p$$
$$cX + dY = q$$

USING CRAMER'S RULE THE SOLUTION MAY BE WRITTEN LIKE THIS:

$$X = \frac{\begin{vmatrix} p & b \\ q & d \end{vmatrix}}{\begin{vmatrix} a & b \\ c & d \end{vmatrix}}, \quad Y = \frac{\begin{vmatrix} a & p \\ c & q \end{vmatrix}}{\begin{vmatrix} a & b \\ c & d \end{vmatrix}}$$

WHERE THE VERTICAL BARS INDICATE *DETERMINANTS* WHICH MAY BE EVALUATED THUS:

$$\begin{vmatrix} a & b \\ c & d \end{vmatrix} = a*d - c*b$$

IF THE DETERMINANT IN THE DENOMINATOR IS ZERO (OR VERY VERY CLOSE TO ZERO) THEN NO SOLUTION IS POSSIBLE.

```
10  PRINT "TWO SIMULTANEOUS EQUATIONS"
20  PRINT "TYPE COEFFICIENTS OF X&Y; FIRST ROW"
30  INPUT A,B
40  PRINT "NOW SECOND ROW"
50  INPUT C,D
60  REM  EVALUATE DENOMINATOR, M
70  LET M = A*D - C*B
80  IF ABS(M) > 0.00001 THEN 110
90  PRINT "SOLUTION IMPOSSIBLE; DET="; M
100 STOP
110 PRINT "TYPE 2 VALUES FOR R.H. SIDE"
120 INPUT P,Q
130 LET X=(P*D-Q*B)/M
140 LET Y=(A*Q-C*P)/M
150 PRINT "X="; X ; "Y="; Y
160 PRINT "ANY MORE R.H.SIDES? YES?"
170 INPUT A$
180 IF A$ = "YES" THEN 110
190 REM  YOU COULD HAVE "STOP" HERE
200 END
```

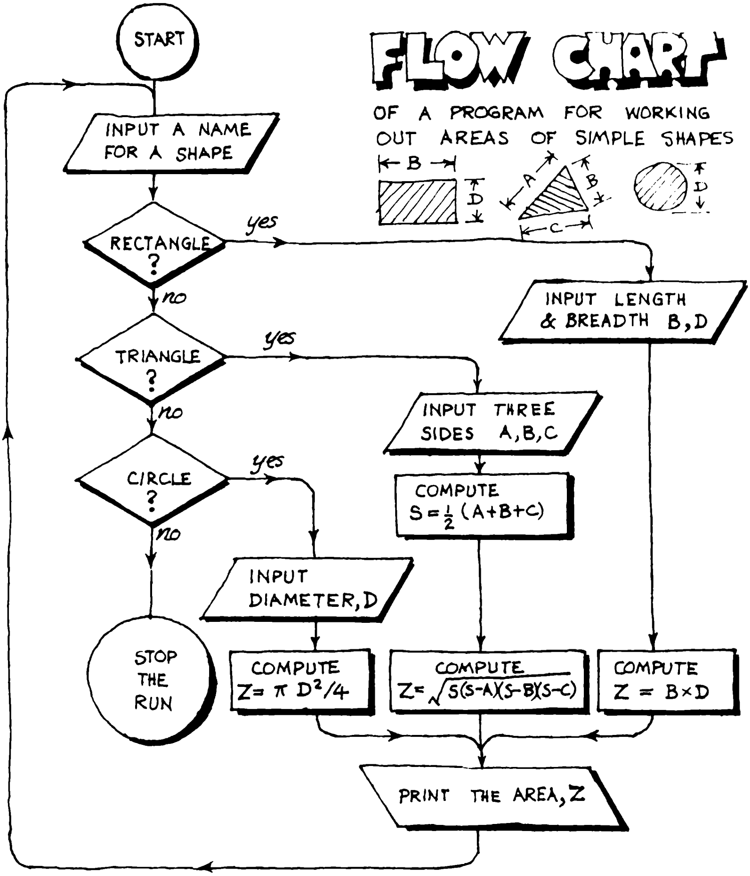
EXAMPLE *ILLUSTRATING* GO TO & IF THEN

HERE IS A PROGRAM DESIGNED TO CALCULATE AREAS OF RECTANGLES, TRIANGLES AND CIRCLES. IT ASKS YOU TO TYPE THE NAME OF A SHAPE; THEN IT ASKS FOR DIMENSIONS RELEVANT TO THAT SHAPE. IF YOU TYPE ANY NAME OTHER THAN "RECTANGLE" "TRIANGLE" OR "CIRCLE" THE PROGRAM STOPS RUNNING.

THE LOGIC OF THE PROGRAM IS SHOWN BY THE *FLOW CHART* BELOW. THERE ARE NICER WAYS OF ORGANIZING SUCH PROGRAMS USING INSTRUCTIONS NOT YET EXPLAINED; THIS PROGRAM WAS DESIGNED TO ILLUSTRATE "GO TO" AND "IF THEN".

FLOW CHART

OF A PROGRAM FOR WORKING OUT AREAS OF SIMPLE SHAPES



```
10  PRINT "***AREA CALCULATOR***"
20  PRINT
30  PRINT "TYPE: RECTANGLE, TRIANGLE OR CIRCLE"
40  INPUT S$
50  REM
60  IF S$= "RECTANGLE" THEN 130
70  IF S$= "TRIANGLE" THEN 180
80  IF S$= "CIRCLE" THEN 240
90  PRINT S$,"MEANS STOP"
100 GO TO 320
110 REM
120 REM
130 PRINT "TYPE BREADTH & DEPTH"
140 INPUT B,D
150 LET Z=B*D
160 GO TO 280
170 REM
180 PRINT "TYPE LENGTHS OF 3 SIDES"
190 INPUT A,B,C
200 LET S=0.5*(A+B+C)
210 LET Z=SQR(S*(S-A)*(S-B)*(S-C))
220 GO TO 280
230 REM
240 PRINT "TYPE THE DIAMETER"
250 INPUT D
260 LET Z=3.141592*D↑2/4
270 REM
280 REM FLOWS MERGE HERE
290 PRINT
300 PRINT "AREA OF "; S$;" IS"; Z
310 GO TO 20
320 END
```

GOES STRAIGHT TO "END"

SPACE

SPACE

```
RUN

***AREA CALCULATOR***

TYPE: RECTANGLE, TRIANGLE OR CIRCLE
? RECTANGLE
TYPE BREADTH & DEPTH
? 14.6 10

AREA OF RECTANGLE IS 146

TYPE: RECTANGLE, TRIANGLE OR CIRCLE
? NO
NO              MEANS STOP
```

ON-GO TO

THIS INSTRUCTION BREAKS THE ORDINARY SEQUENCE OF OBEYING INSTRUCTIONS

IT IS A MULTI-WAY SWITCH.

```
80 ON D+1 GO TO 100,110,120,130
```

VARIABLE OR EXPRESSION

ONE WORD OR TWO

LIST OF LINE NUMBERS (NOT EXPRESSIONS) ALL NUMBERED LINES MUST EXIST

BASIC EVALUATES THE EXPRESSION AND:

- SOME *BASICS* "ROUND" THE RESULT TO THE *NEAREST INTEGER*.
- SOME *BASICS* TAKE THE *INTEGRAL PART*.

IF THE RESULT IS 1 THEN *BASIC* USES THE *FIRST* NUMBER IN THE LIST (GO TO 100). IF THE RESULT IS 2 THEN *BASIC* USES THE *SECOND* NUMBER (GO TO 110) AND SO ON.

```
10  PRINT "TYPE A DIGIT FROM 0 TO 3"
15  PRINT "PRESS 'BREAK' KEY TO STOP"
30  INPUT D
40  IF D-INT(D)<>0 THEN 140
50  IF D<0 THEN 150
60  IF D>3 THEN 150
65  REM  NOW CERTAIN D IS 0,1,2 OR 3
70  PRINT "YOU TYPED ";
75  REM
80  ON D+1 GO TO 100, 110, 120, 130
85  REM CAN'T GET HERE
100 PRINT "ZERO"
105 GO TO 10
110 PRINT "ONE"
115 GO TO 10
120 PRINT "TWO"
125 GO TO 10
130 PRINT "THREE"
135 GO TO 10
140 PRINT "NON INTEGRAL"
145 GO TO 10
150 PRINT "OUT OF RANGE"
160 GO TO 10
170 END
```

(CONTINUED OPPOSITE)

```
RUN

TYPE A DIGIT FROM 0 TO 3
PRESS 'BREAK' TO STOP
? 0
YOU TYPED ZERO
TYPE A DIGIT FROM 0 TO 3
PRESS 'BREAK' TO STOP
? 6
OUT OF RANGE
TYPE
```

THIS IS A USEFUL INSTRUCTION, BUT BE CAREFUL ABOUT ITS SPECIAL *INTERPRETATIONS* BY DIFFERENT VERSIONS OF *BASIC*.

- ☆ BECAUSE SOME *BASICS* USE THE *NEAREST* INTEGER AND OTHERS THE *INTEGRAL PART* OF THE EXPRESSION, ENSURE YOUR OWN EXPRESSIONS CAN ONLY YIELD INTEGRAL RESULTS (SEE LINE 40 OPPOSITE).

- ☆ SOME *BASICS* REPORT AN ERROR AND STOP THE RUN IF THE RESULT OF THE EXPRESSION IS OUT OF RANGE. BUT OTHER *BASICS* GO TO THE *FIRST* LINE IN THE LIST IF THE RESULT IS LESS THAN 1 AND TO THE *LAST* IF THE RESULT IS GREATER THAN THE NUMBER OF NUMBERS IN THE LIST. YET OTHER *BASICS* JUMP TO THE LINE FOLLOWING "ON" (LINE 85 OPPOSITE) IF THE RESULT IS OUT OF RANGE. SO FOR THE SAKE OF "PORTABILITY" *PUT IN YOUR OWN TESTS FOR RANGE* (SEE LINES 50 & 60 OPPOSITE).

BELOW ARE SHOWN OTHER (LESS COMMON) FORMS OF THIS INSTRUCTION AS USED IN DIFFERENT VERSIONS OF *BASIC*.

```
80 ON D+1 THEN 100, 110, 120, 130
```

```
80 GOTO 100, 110, 120, 130 ON D+1
```

```
80 GOTO D+1 OF 100, 110, 120, 130
```

THE INSTRUCTION BELOW MAY BECOME UNIVERSAL *IN ADDITION* TO THE "ON ≈ GO TO" DESCRIBED ABOVE. THE MEANING OF "ON ≈ GO SUB" WILL BE CLEAR WHEN YOU REACH PAGE 55.

```
80 ON D+1 GO SUB 100, 110, 120, 130
```

FOR-NEXT

THIS MAKES BASIC OBEY A SEQUENCE OF INSTRUCTIONS AGAIN & AGAIN

WE CALL THIS SEQUENCE A *LOOP*.

```
10  LET M=3
20  READ X$
30  PRINT M;X$
40  LET M=M-1
50  IF M<>0 THEN 20
60  PRINT "PEAR TREE"
70  DATA "HENS","DOVES","PARTRIDGE"
80  END

RUN

 3 HENS
 2 DOVES
 1 PARTRIDGE
PEAR TREE
```

YOU CAN CREATE A LOOP BY SETTING A "COUNTER" (LET M=3) THEN SUCCESSIVELY DEDUCTING 1 (LET M=M-1), TESTING THE REMAINING VALUE (IF M<>0), AND "LOOPING" BACK (THEN 20) UNTIL THE COUNTER RUNS OUT.

BUT THE SAME RESULT MAY BE ACHIEVED MORE SIMPLY AS SHOWN HERE ⇒

```
10  FOR M = 3 TO 1 STEP -1
20  READ X$
30  PRINT M;X$
40  NEXT M
50  PRINT "PEAR TREE"
60  DATA "HENS","DOVES","PARTRIDGE"
70  END
```

THE FORM OF THE INSTRUCTION IS:

ANY NUMERICAL VARIABLE

EXPRESSIONS OF ANY COMPLEXITY HERE

```
10 FOR M = 3 TO 1 STEP -1
```

INSTRUCTIONS TO BE OBEYED SUCCESSIVELY

```
NEXT M
```

SAME VARIABLE AS BEFORE

IF THE STEP IS +1 THEN YOU MAY SIMPLIFY BY OMITTING "STEP 1":

```
100 FOR N = P TO Q
```

LOOPS MAY BE *NESTED* ONE INSIDE THE OTHER.

```
10 PRINT "OLD GLORY (A.D. 1912)"
20 FOR R = 1 TO 7
30 LET P$= "  "
40 IF R=1 THEN 60
50 LET P$= "* "
60 FOR C = 1 TO 8
70 PRINT P$;
80 NEXT C
90 IF R-2*INT(R/2)=0 THEN 130
100 FOR C = 1 TO 12
110 PRINT "==";
120 NEXT C
130 PRINT
140 NEXT R
150 FOR R = 1 TO 3
160 PRINT
170 FOR C = 1 TO 20
180 PRINT "==";
190 NEXT C
200 PRINT
210 NEXT R
220 END
```

2 SPACES

1 SPACE

JUMPS WHEN R IS EVEN

TRY IT!

THERE IS ALWAYS SOME LIMIT TO THE PERMISSIBLE DEPTH OF NESTING. A TYPICAL LIMIT IS ABOUT 10 WHICH IS AMPLE DEPTH FOR EVEN THE MOST COMPLICATED PROGRAM.

LOOPS MUST NOT BE INTERLEAVED.

```
10 FOR I=
20 FOR K=

60 NEXT I
70 NEXT K
```

YOU MAY *JUMP OUT* OF A LOOP:

```
10  REM  FIND YOUR PLACE ON THE MARE†
20  DATA "BREWER", "STEWER", "GURNEY"
30  DATA "DAVEY", "WHIDDON", "HAWK"
40  DATA "COBBLEIGH"
50  PRINT "TYPE YOUR LAST NAME"
60  INPUT N$
70  FOR L= 1 TO 7
80  READ M$
90  IF M$=N$ THEN 130
100 NEXT L
110 PRINT N$;" IS NOT ON THE MARE"
120 GO TO 140
130 PRINT N$;" IS NUMBER";L
140 END
```

† *OLDE ENGLISHE FOLKE SONGE "WIDDICOMBE FAIR"*

THIS IS CALLED *SCANNING A LIST* TO FIND A MATCH.

THE *LOOPING VARIABLE* (L ABOVE) KEEPS ITS VALUE IF YOU JUMP OUT OF A LOOP BEFORE THE LOOP HAS RUN ITS COURSE. BUT IF YOU *DROP OUT AT THE BOTTOM* (IN THIS CASE TO LINE 110) THEN **DON'T** ASSUME ANYTHING ABOUT THE VALUE OF THE LOOPING VARIABLE: IT MIGHT BE 8 ABOVE (THIS IS EXPLAINED OVERLEAF) *BUT IT MIGHT NOT. BASICS DIFFER.*

LOOPS (CONTINUED)

YOU SHOULD NEVER JUMP INTO THE MIDDLE OF A LOOP:

```
120  IF A>2  THEN  210

200  FOR I = 1 TO 6
210  PRINT "*";
220  NEXT I
230  LET A=A-1
```

BASIC WOULD NOT OBEY A "NEXT" IF IT HAD NOT PREVIOUSLY OBEYED THE MATCHING "FOR".

BUT IN MOST *BASICS* YOU MAY JUMP OUT OF A LOOP AND THEN BACK IN AGAIN (NOT A VERY GOOD PRACTICE).

```
150  FOR I=1 TO 6
160  READ M$
170  IF  M$=N$  THEN 300
180  NEXT I

300  PRINT M$
310  GO TO 180
```

THE JARGON FOR THIS IS A LOOP WITH *EXTENDED RANGE*.

IN GENERAL YOU SHOULD ENTER A LOOP THROUGH ITS "FOR" STATEMENT AND EITHER:

- FALL THROUGH AT THE "NEXT", OR
- JUMP OUT AND STAY OUT.

IF YOU NEED EXTENDED RANGE THEN ACHIEVE IT USING THE "*GO SUB*" INSTRUCTION DESCRIBED ON PAGE 52.

IF A PROGRAM IS NOT SUPPOSED TO EXECUTE A LOOP *AT ALL* UNDER CERTAIN CONDITIONS THEN IT IS SAFEST TO TEST FOR THOSE CONDITIONS, AND, IF THEY APPLY, TO AVOID THE LOOP ALTOGETHER.

```
10  FOR I= 1 TO 5
20  READ  C
30  PRINT  C;
40  IF C <= 0 THEN 80
50  FOR  R = 1 TO C
60  PRINT "*";
70  NEXT R
80  PRINT
90  NEXT I
100 DATA   3, 0,-1, 4, 1
110 END
```

MISS THE LOOP RUNNING FROM 1 TO C WHEN C≤0

```
RUN

 3 ***
 0
-1
 4 ****
 1 *
```

THE REASON FOR THIS PRECAUTION IS GIVEN OPPOSITE.

ALTHOUGH THE CONCEPT SEEMS SIMPLE THERE ARE HIDDEN DANGERS WITH LOOPS; DIFFERENT *BASICS* DEAL WITH THEM DIFFERENTLY. HERE IS THE INTERPRETATION IN MORE THAN ONE *STANDARD BASIC*.

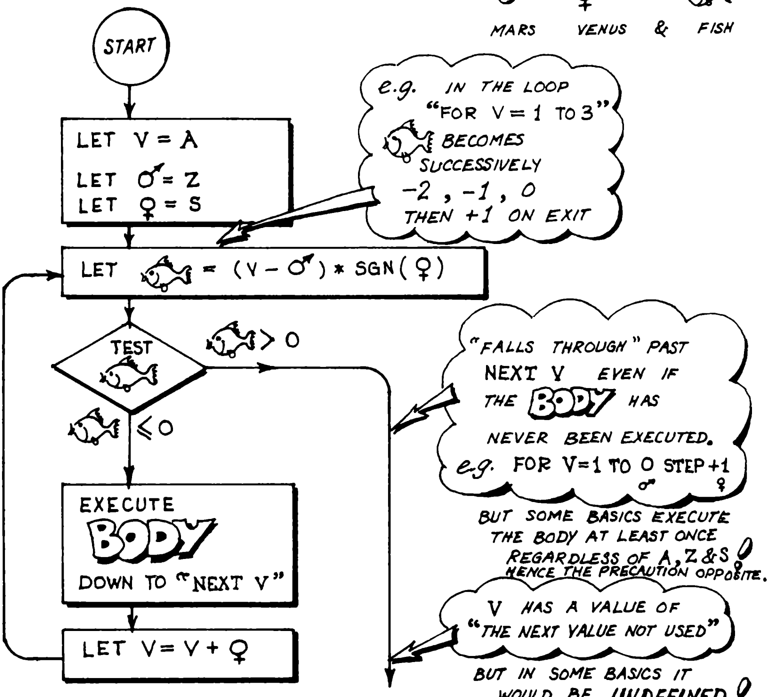
CONSIDER THIS LOOP:

WHERE A, Z & S COULD BE COMPLICATED EXPRESSIONS

```
10 FOR V = A TO Z STEP S
BODY
40 NEXT V
```

THE INTERPRETATION INVOLVES 3 VARIABLES WHICH *BASIC* ITSELF CAN USE BUT WHICH YOU, *THE USER*, CAN NEITHER REFER TO NOR CHANGE. CALL THEM: ♂ ♀

MARS VENUS & FISH



THIS LOGIC IMPLIES NO MATTER WHAT CHANGES YOU MAKE TO A, Z OR S IN THE BODY OF THE LOOP IT WILL NOT AFFECT THE NUMBER OF TIMES ROUND THE LOOP. BUT YOU SHOULD *NEVER* CHANGE THE VALUE OF V IN THE BODY OF THE LOOP.

REMEMBERING THAT MANY *BASICS* DON'T USE THIS LOGIC, *NEVER CHANGE ANYTHING IN THE BODY THAT COULD ALTER THE VALUE OF* V, A, Z *OR* S. *KEEP THE CONTROLS SIMPLE!*

GO SUB – RETURN

IN MANY PROGRAMS A PARTICULAR SEQUENCE OF INSTRUCTIONS OCCURS SEVERAL TIMES. IN SUCH CASES YOU DON'T HAVE TO *REPRODUCE* THAT SEQUENCE SEVERAL TIMES; YOU MAY PARCEL IT UP AS A *SUBROUTINE* AND SIMPLY GO TO THAT SUBROUTINE FROM ANY LINE IN THE PROGRAM AND RETURN TO THE PLACE FROM WHENCE YOU CAME.

THE PROGRAM CALLED "OLD GLORY" ON PAGE 49 HAS A SEQUENCE OCCURRING THREE TIMES:

```
FOR C = 1 TO something
PRINT something;
NEXT C
```

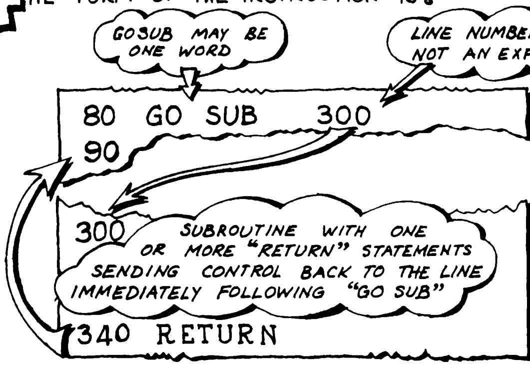
WHICH COULD BE PARCELLED UP AS A SUBROUTINE:

```
300 REM  SUBROUTINE WITH B & P$
310 FOR  I = 1 TO B
320 PRINT  P$;
330 NEXT I
340 RETURN
```

AND THE PROGRAM "OLD GLORY" RE-CAST LIKE THIS:

```
10   PRINT "OLD GLORY WITH GO SUB & RETURN"
20   FOR R = 1 TO 7
30   LET P$ = "  "                  2 SPACES
40   IF R = 1 THEN 70
50   LET P$ = "* "                  SPACE
70   LET B=8
80   GO SUB 300                     GOES TO 300 RETURNS TO 90
90   IF R-2*INT(R/2)=0 THEN 130
100  LET B=12
110  LET P$ = "=="
120  GO SUB 300                     RETURNS TO 130
130  PRINT
140  NEXT R
150  FOR R = 1 TO 3
160  PRINT
170  LET B=20
180  GO SUB 300                     RETURNS TO 200
200  PRINT
210  NEXT R
220  GO TO 900                      MISS THE SUBROUTINE
                                    INSERT SUBROUTINE HERE
900  END
```

THE FORM OF THE INSTRUCTION IS:



THIS IS KNOWN IN THE JARGON AS *CALLING* A SUBROUTINE.

NOTE: SUBROUTINES MAY THEMSELVES CONTAIN "GO SUB" STATEMENTS.

"GO SUB" MAY BE ANYWHERE IN THE PROGRAM; THE SUBROUTINE BEING CALLED MAY ALSO BE ANYWHERE (NOT NECESSARILY ON HIGHER-NUMBERED LINES). YOU NEED CAREFUL ORGANIZATION TO PREVENT AN IMPOSSIBLE TANGLE.

A FEW *BASICS* ALLOW *DUMMY PARAMETERS* IN A SUBROUTINE. (THEY WORK IN THE MANNER EXPLAINED ON PAGE 26 IN CONNECTION WITH DUMMY ARGUMENTS OF FUNCTIONS.) HERE AGAIN DETAILS VARY A LOT FROM *BASIC* TO *BASIC* AND YOU SHOULDN'T USE DUMMY PARAMETERS IF YOU WANT "PORTABLE" PROGRAMS.

TAKE CARE NOT TO "FALL" INTO A SUBROUTINE BY ACCIDENT. NOTICE LINE 220 OPPOSITE: IF THIS WERE OMITTED THERE WOULD BE SUCH A "FALL".

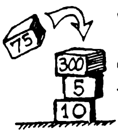
CONTINUED OVERLEAF.

GO SUB (CONTINUED)

NOVICES TO PROGRAMMING MAY CARE TO SKIP THIS DOUBLE PAGE THE FIRST TIME THROUGH THE BOOK

"GO SUB" MAY APPEAR ANYWHERE IN A PROGRAM; LIKEWISE THE SUBROUTINE BEING CALLED MAY BE ANYWHERE. *BASIC* HAS NO SURE WAY OF ASSOCIATING A "RETURN" WITH THE PARTICULAR "GO SUB" OF *YOUR* INTENTION. (IT'S NOT LIKE "FOR V =" FOLLOWED BY "NEXT V" WHERE THE "V" MAKES THE ASSOCIATION CLEAR.) SO WE DESCRIBE BELOW HOW *BASIC* IS ABLE TO MAKE SUCH AN ASSOCIATION.

SOME *BASICS* DEAL WITH "GO SUB" BY A TECHNIQUE CALLED *STACKING*. THE STACK WORKS LIKE THIS:



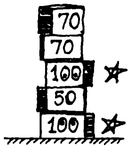
WHEN *BASIC* MEETS "GO SUB" IT NOTES THE NUMBER OF THE LINE IMMEDIATELY FOLLOWING "GO SUB" AND PUTS THIS NUMBER ON THE TOP OF THE STACK: THEN CONTROL GOES TO THE LINE NOMINATED AFTER "GO SUB".

WHEN *BASIC* MEETS A "RETURN" IT SIMPLY LOOKS AT THE NUMBER CURRENTLY AT THE *TOP* OF THE STACK; GOES STRAIGHT TO THE LINE HAVING THAT NUMBER; THEN *THROWS AWAY* THAT NUMBER FROM THE TOP OF THE STACK.

THIS LOGIC IMPLIES THAT IF *BASIC* MEETS A "RETURN" BEFORE THE VERY FIRST "GO SUB" THEN THERE WILL BE AN EMPTY STACK, HENCE NOWHERE TO GO — OFTEN A BUG IN THE PROGRAM CAUSING CONTROL TO "*FALL*" INTO A SUBROUTINE. ON THE OTHER HAND *BASIC* MAY KEEP MEETING "GO SUB" BUT NOT ENOUGH "RETURNS" RESULTING IN THE STACK FILLING TO CAPACITY (WHICH VARIES FROM *BASIC* TO *BASIC* BUT IS TYPICALLY 10).

ALTHOUGH NOT ALL *BASICS* USE THIS PRECISE MECHANISM FOR HANDLING "GO SUB" YOU MAY ***THINK*** OF IT THIS WAY WHEN TESTING THE PROPOSED LOGIC OF A PROGRAM YOU ARE GOING TO WRITE, WHEN TRACKING DOWN BUGS IN A PROGRAM, AND WHEN TRYING TO FIGURE OUT THE LOGIC OF SOMEONE ELSE'S PROGRAM.

WHETHER OR NOT YOUR OWN *BASIC* HANDLES "GO SUB" USING A STACK IS ONLY IMPORTANT IF YOU WRITE A SUBROUTINE THAT *CALLS ITSELF*. THIS IS KNOWN AS *RECURSION* AND IS ONLY FEASIBLE WITH THE LOGIC OF THE STACK EXPLAINED ABOVE.



THIS STACK SHOWS THAT THE LAST "GO SUB" TO BE OBEYED IS THE SAME AS THE PREVIOUS ONE ⇐ INDICATING THAT A SUBROUTINE HAS JUST CALLED ITSELF *DIRECTLY*. EARLIER A SUBROUTINE HAD CALLED ANOTHER WHICH, IN TURN, HAD CALLED THE FIRST ONE AS SHOWN BY THE ☆ ON THE PICTURE. THUS A SUBROUTINE HAD CALLED ITSELF *INDIRECTLY*.

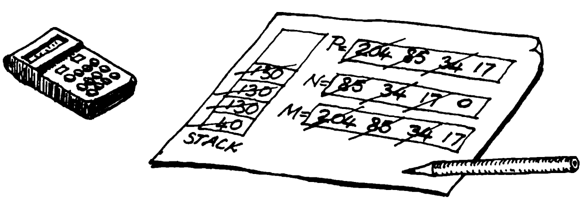
YOU MAY DISCOVER IF YOUR VERSION OF *BASIC* ALLOWS SUBROUTINES TO CALL THEMSELVES. TRY THE FOLLOWING LITTLE PROGRAM WHICH FINDS THE HIGHEST COMMON FACTOR OF TWO NUMBERS BY EUCLID'S METHOD.

```
10   PRINT "TYPE 2 POSITIVE INTEGERS"
20   INPUT  M,N
30   GO SUB  70        <= CALLS SUBROUTINE
40   PRINT  "THEIR H.C.F. IS "; P
50   GO TO  140        <= STOPS (DOESN'T FALL THRO' SUBROUTINE)
60   REM  END OF PROGRAM
70   REM  START OF SUBROUTINE
80   LET  P=N
90   LET  N=M-N*INT(M/N)
100  LET  M=P
110  IF   N=0  THEN  130   <= RETURNS IF N=0
120  GO SUB 70         <= CALLS ITSELF IF N≠0
130  RETURN
140  END
```

YOUR OWN *BASIC* MAY WELL SAY THERE ARE NOT ENOUGH "RETURNS" ⇐ IN WHICH CASE IT PROBABLY DOESN'T USE THE LOGIC OF A STACK. (YOU MAY THEN CHANGE LINE 120 TO "GO TO 70" AND IT SHOULD WORK.)

IF YOUR *BASIC* ACCEPTS THE PROGRAM WITHOUT ANY ALTERATION TO LINE 120 THEN YOU MAY EXPERIMENT TO FIND THE LIMITING HEIGHT OF THE STACK. THUS IF YOU TYPE 85, 204 THE PROGRAM WILL PRINT THE RESULT WHICH IS 17. BUT IF YOU TYPE 85, 289 THEN THE ALLOWABLE STACKING HEIGHT WILL PROBABLY BE EXCEEDED ALTHOUGH THE ANSWER IS STILL 17.

TRY "PLAYING COMPUTERS" USING PENCIL, PAPER AND POCKET CALCULATOR. THIS SHOULD REVEAL EUCLID'S METHOD AND ALSO SHOW HOW THE STACK BUILDS UP AND COLLAPSES.

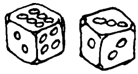


MOO

THIS IS AN INFURIATING GAME.

THE PROGRAM SHOWN HERE WAS DESIGNED TO PLAY "MOO" AND ILLUSTRATE "GO SUB".

HOW TO PLAY



START BY THROWING TWO DICE. AS EACH DIE IS CAST TYPE ITS SCORE ON THE KEYBOARD. (THIS MAKES SURE YOU DON'T PLAY THE SAME GAME EVERY TIME.)

THE COMPUTER CHOOSES A NUMBER WITH FOUR DIGITS — *NO TWO ALIKE* — (NOTE: THE FIRST DIGIT COULD BE ZERO).

YOU GUESS WHAT NUMBER THE COMPUTER HAS CHOSEN AND TYPE YOUR GUESS WHEN INVITED TO DO SO.

THE COMPUTER NOTES HOW MANY OF YOUR DIGITS ARE RIGHT — *BUT IN THE WRONG PLACE* — EACH OF THESE IT CALLS A *COW*.

THE COMPUTER NOTES HOW MANY OF YOUR DIGITS ARE NOT ONLY RIGHT — *BUT ALSO IN THE RIGHT PLACE* — EACH OF THESE IT CALLS A *BULL*.

HAVING REPORTED YOUR SCORE OF *BULLS & COWS* THE COMPUTER INVITES YOU TO GUESS AGAIN — AND SO ON UNTIL YOU SCORE *FOUR* BULLS AND *NO* COWS.

HERE IS THE PROGRAM:

```
5   REM   THE GAME OF MOO
10  PRINT "THROW TWO DICE"
15  INPUT I,J
20  FOR K = 0 TO 6*I+J-7
25  LET X = RND     <- POSSIBLY RND(0)
30  NEXT K
35  REM  NOW FOR THE PROGRAM PROPER
```

```
110  LET X=INT(10000*RND)
120  LET Y= X
130  GO SUB 1000                      CHECK NO TWO DIGITS ALIKE
140  IF C>0 THEN 110
150  REM   NO COWS ON COMPARISON WITH SELF
160  PRINT "I HAVE CHOSEN A 4-DIGIT NUMBER"
170  LET T=0                          COUNT THE TRIES
180  LET T=T+1
190  PRINT "WHAT'S YOUR GUESS"
200  INPUT X                          COMPARE
210  GO SUB 1000                      GUESS WITH NUMBER
220  PRINT B;"BULLS &"; C; "COWS"
230  IF B<4 THEN 180
240  PRINT "THAT TOOK"; T; "TRIES"
250  PRINT                            START A NEW
260  GO TO 110                        GAME
265  REM  STOP THIS GAME WITH 'BREAK' KEY
1000 REM        SUBROUTINE
1010 LET B=0   BULLS
1020 LET C=0   COWS                   PICK EACH DIGIT
1030 FOR I = 1 TO 4                   OF GUESS IN TURN
1040 LET K = 10↑I
1050 LET L = INT(10*(X-K*INT(X/K)+.1)/K)
1060 FOR J = 1 TO 4                   COMPARE EACH DIGIT
1070 LET M= 10↑J                      OF NUMBER WITH Ith DIGIT OF GUESS
1075 LET P = INT(10*(Y-M*INT(Y/M)+.1)/M)
1080 IF L<>P THEN 1130
1090 LET C= C+1                       THE 0·1 COMPENSATES
1100 IF I<>J THEN 1130                FOR ROUNDING ERRORS
1110 LET C = C-1                      INT(3·99999) IS 3
1120 LET B= B+1                       INT(3·99999+·1) IS 4
1130 NEXT J
1140 NEXT I
1150 RETURN
1160 REM
1200 END

RUN

THROW 2 DICE
? 6,3
I HAVE CHOSEN A 4-DIGIT NUMBER
WHAT'S YOUR GUESS
? 1234
 0 BULLS & 2 COWS
WHAT'S YOUR GUESS
? 5678                  AND SO ON      EVENTUALLY
THAT TOOK 6 TRIES
```

4

ARRAYS

ARRAYS

IN *ADDITION* TO THE *SIMPLE* NUMERICAL & TEXTUAL VARIABLES YOU MAY USE THOUSANDS OF OTHER VARIABLES ARRANGED IN *ARRAYS*.

BELOW IS AN EXAMPLE OF A *ONE-DIMENSIONAL* NUMERICAL ARRAY CALLED A( ).

A(1)	3.56
A(2)	7.12
A(3)	10.68
A(4)	

A( ) HAS *ELEMENTS*, EACH OF WHICH CAN STORE A NUMBER IN THE SAME WAY AS ANY *SIMPLE* NUMERICAL VARIABLE:

```
100   LET   A(1) = 3.56
110   LET   A(2) = 7.12
120   LET   A(3) = A(1) + A(2)
```

ANOTHER NAME FOR *ELEMENT* IS *SINGLY-SUBSCRIPTED VARIABLE* (OR JUST *SUBSCRIPTED VARIABLE* IF THE CONTEXT ALLOWS).

OTHER NAMES FOR A ONE-DIMENSIONAL ARRAY ARE: *VECTOR*, *COLUMN VECTOR*, & *COLUMN MATRIX*. YOU CAN ALSO THINK OF A( ) AS A ROW:

A(1)	A(2)	A(3)	A(4)
3.56	7.12	10.68	

AND CALL IT A *ROW VECTOR* OR *ROW MATRIX*.

BELOW IS AN EXAMPLE OF A *TWO-DIMENSIONAL* NUMERICAL ARRAY CALLED B(,). IT HAS 4 ROWS AND 3 COLUMNS.

	1)	2)	3)
B(1,	8.92		
B(2,		17.84	−8.92
B(3,			
B(4,			

JUST AS WITH A( ), B(,) HAS *ELEMENTS* EACH OF WHICH CAN STORE A NUMBER IN THE SAME WAY AS A SIMPLE NUMERICAL VARIABLE:

```
130   LET   B(1,1) = 8.92
140   LET   B(2,2) = 2 * B(1,1)
150   LET   B(2,3) = -B(1,1)
```

ANOTHER NAME FOR AN ELEMENT OF A *TWO*-DIMENSIONAL ARRAY IS *DOUBLY-SUBSCRIPTED VARIABLE* (OR JUST *SUBSCRIPTED VARIABLE* WHEN THE CONTEXT ALLOWS).

OTHER NAMES FOR A TWO-DIMENSIONAL ARRAY ARE *RECTANGULAR ARRAY* AND *RECTANGULAR MATRIX*. (IF THE NUMBER OF ROWS IS THE SAME AS THE NUMBER OF COLUMNS THEN *SQUARE* MAY BE SAID IN PLACE OF *RECTANGULAR*.)

A FEW *BASICS* ALLOW *THREE*-DIMENSIONAL ARRAYS.

BELOW IS AN EXAMPLE OF A *TEXTUAL* ARRAY CALLED T$(). IT IS *ONE-DIMENSIONAL* (SEVERAL *BASICS* DON'T ALLOW TWO-DIMENSIONAL TEXTUAL ARRAYS SO FOR THE SAKE OF "PORTABILITY" IT IS BEST TO DO WITHOUT THEM).

T$(1)	HO
T$(2)	
T$(3)	KEGRAPHA
T$(4)	
T$(5)	KEGRAPHA

T$( ) HAS ELEMENTS EACH OF WHICH CAN STORE A TEXT IN THE SAME WAY (AND USUALLY TO THE SAME LENGTH) AS ANY SIMPLE TEXTUAL VARIABLE.

```
160  LET  T$(1)="HO"
170  LET  T$(3)="KEGRAPHA"
180  LET  T$(5)=T$(3)
```

YOUR PROGRAM MAY HAVE UP TO 26 NUMERICAL ARRAYS:

A( ) , B( ), C( ), . . ., Z( )

OF WHICH SOME MAY BE *ONE*-DIMENSIONAL AND SOME *TWO*-DIMENSIONAL: ONE LETTER CAN'T BE MADE TO SERVE FOR BOTH KINDS AT ONCE.

YOUR PROGRAM MAY ALSO HAVE UP TO 26 TEXTUAL ARRAYS:

A$( ), B$( ), C$( ), . . ., Z$( )

AND YOUR PROGRAM MAY USE ALL 286 SIMPLE NUMERICAL VARIABLES AND ALL 26 SIMPLE TEXTUAL VARIABLES WHICH ARE COMPLETELY DISTINCT FROM ELEMENTS OF ARRAYS: B(2,2) HAS NOTHING TO DO WITH B ; T$(5) HAS NOTHING TO DO WITH T$.

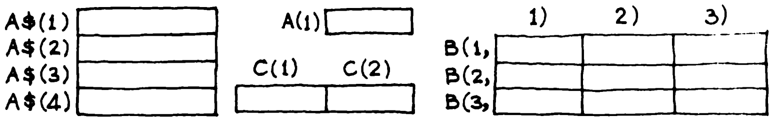
SPECIFY THE SIZES AND SHAPES OF THE ARRAYS YOU WANT TO USE BY THE "DIM" STATEMENT (SHORT FOR *DIMENSION*) AS EXPLAINED OVERLEAF. THE ARRAYS ON THIS DOUBLE PAGE WOULD BE SPECIFIED LIKE THIS:

```
10   REM  A PROGRAM WITH ARRAYS
20   DIM  A(4), B(4,3), T$(5)
```

DIM

— DIM IS SHORT FOR *DIMENSION* — USE THIS STATEMENT TO SPECIFY THE DIMENSIONS OF *ALL* ARRAYS IN YOUR PROGRAM.

THE FOLLOWING SELECTION OF ARRAYS:



MAY BE SPECIFIED IN ONE "DIM" STATEMENT:

```
10  REM   PROGRAM WITH ONE DIM
20  DIM  A$(4), A(1), C(2), B(3,3)
```

OR IN MORE THAN ONE "DIM" STATEMENT:

```
10  REM  PROGRAM WITH SEVERAL DIMS
20  DIM  C(2), A(1)
30  DIM  B(3,3)
40  DIM  A$(4)
```

INTEGERS ONLY: EXPRESSIONS NOT ALLOWED

MANY *BASICS* ALLOW YOU TO *OMIT* "DIM" STATEMENTS WHEN DIMENSIONS ARE 10 OR LESS, BUT DON'T TAKE ADVANTAGE OF THIS. IF YOU GO BACK TO A PROGRAM WRITTEN LONG AGO — OR HAVE TO SORT OUT SOMEONE ELSE'S PROGRAM — *IT IS HELPFUL TO KNOW STRAIGHT AWAY WHAT ARRAYS ARE BEING USED*. IN ANY CASE THERE ARE SOME *BASICS* THAT DEMAND DECLARATION OF ALL ARRAYS HOWEVER SMALL.

ALL "DIM" STATEMENTS SHOULD BE NEAR THE BEGINNING OF THE PROGRAM — BEFORE THE FIRST USE OF ANY SUBSCRIPTED VARIABLES AFFECTED — AND YOU SHOULD ENSURE THAT "DIM" STATEMENTS (LIKE "DEF" STATEMENTS ON PAGE 26) ARE ACTUALLY ENCOUNTERED DURING EXECUTION.

```
50  LET  P(1) = 4.5
60  DIM  P(16)
```

```
10  GO TO  30
20  DIM  A(40,40), B(1000)
30
```

IN MANY *BASICS* THESE THINGS DON'T MATTER BUT IN SOME THEY *DO* — SO FOR THE SAKE OF "PORTABILITY" ACCEPT SUCH LITTLE RESTRICTIONS.

IT IS ALWAYS A MISTAKE TO DECLARE AN ARRAY MORE THAN ONCE.

```
10  DIM  A(100,20), B(60)
20  DIM  B(60), C(500)
```

HISTORICALLY THE ROWS & COLUMNS OF ARRAYS IN *BASIC* WERE COUNTED FROM *ZERO* RATHER THAN UNITY.

	0)	1)	2)	3)
P(0,				
P(1,				
P(2,				

Q(0)	
Q(1)	
Q(2)	

AND THE "DIM" STATEMENT REFERRED TO *BIGGEST SUBSCRIPTS* RATHER THAN QUANTITIES OF ROWS AND COLUMNS:

```
10  REM   HISTORICAL BASIC
20  DIM   P(2,3) , Q(2)
```

BUT THERE ARE VERSIONS OF *BASIC* TODAY THAT COUNT FROM *UNITY* (AS IN THE ILLUSTRATIONS OPPOSITE) SO IT IS SAFEST TO *IMAGINE* YOUR VERSION COUNTS FROM 1. IF, IN FACT, IT COUNTS FROM ZERO IT MEANS YOU ARE WASTING SOME SPACE IN THE COMPUTER'S STORE BUT AT LEAST YOUR PROGRAM SHOULD BE "PORTABLE".

SOME *BASICS* CATER FOR BOTH METHODS WITH THE STATEMENT:

```
10  BASE  0
```

OR:

```
10  BASE  1
```

TO DECLARE WHETHER YOU WISH TO COUNT FROM ZERO OR UNITY RESPECTIVELY.

THE "DIM" STATEMENT MAKES *BASIC* RESERVE SPACE IN THE COMPUTER'S STORE FOR ALL YOUR ARRAYS, BUT THIS DOESN'T IMPLY THAT *BASIC* CLEARS THEM OF INFORMATION LEFT OVER FROM A PREVIOUS COMPUTER RUN. SOME *BASICS* DO SET SUBSCRIPTED VARIABLES TO ZERO (BLANKS IN THE CASE OF TEXTS), OTHERS "FLAG" THEM AS UNSET (AS DISCUSSED FOR SIMPLE VARIABLES ON PAGE 11), AND OTHERS LEAVE THEM FULL OF "GARBAGE". SO IF YOUR PROGRAM READS FROM AN ARRAY:

```
100  LET  A = B(2,2)
```

EXPECTING TO FIND ZERO WHEN NOTHING HAS YET BEEN PUT THERE, *MAKE SURE YOUR PROGRAM CLEARS THE ARRAY FIRST*. THE SIMPLEST WAY TO DO THIS IS EXPLAINED ON PAGE 86 WHICH WE ANTICIPATE WITH THIS EXAMPLE:

```
70  MAT  B = ZER
```

SETS ALL ELEMENTS OF ARRAY B(,) TO ZERO

SUBSCRIPTS

THE FOLLOWING ARRAY:

```
10 DIM  B(4,3)
```

	1)	2)	3)
B(1,			
B(2,			
B(3,			
B(4,			

IS AN ARRAY OF 12 SUBSCRIPTED VARIABLES EACH OF WHICH CAN BE USED AS THOUGH IT WERE A *SIMPLE* NUMERICAL VARIABLE:

```
100 LET  B(1,2) = B(2,2)↑2 + 6.8
110 LET  B(3,3) = FNC( B(1,1)/B(2,2))
120 PRINT  B(1,2); B(3,3)
130 FOR  I = B(1,1)  TO  B(1,2) STEP B(1,3)
140 IF  B(3,3) >=  B(2,3) THEN  600
```

EXAMPLES OF SYNTAX: THE CONTENT IS MEANINGLESS

THIS APPLIES TO TEXTUAL VARIABLES TOO:

```
150 LET  T$(6) = "PONZIO"
160 IF   T$(7) <> "PILATO" THEN 200
170 PRINT   T$(6); T$(7)
```

IN ANY EXPRESSION WHERE A *SIMPLE* VARIABLE IS ALLOWED A *SUBSCRIPTED* VARIABLE IS ALSO ALLOWED.

BUT THERE ARE PLACES OUTSIDE EXPRESSIONS WHERE YOU *CAN'T* HAVE A SUBSCRIPTED VARIABLE:

NOT AS A LOOPING VARIABLE:

```
180  FOR  B(1,1) = 1 TO 3
```

```
190 DEF  FNC( B(1,1) ) =  SQR(A↑2 + B↑2)
```

NOT AS THE DUMMY ARGUMENT OF A FUNCTION.

THE *REAL* ADVANTAGE OF SUBSCRIPTED VARIABLES, HOWEVER, IS NOT AS A SUBSTITUTE FOR SIMPLE VARIABLES BUT BECAUSE THEIR

SUBSCRIPTS MAY BE VARIABLES + EXPRESSIONS

EVEN COMPLICATED EXPRESSIONS, THEMSELVES CONTAINING SUBSCRIPTED VARIABLES.

THUS IT IS SIMPLE TO READ A ROW OR COLUMN VECTOR:

```
200 DATA "A","B","C","D"
210 FOR I = 1 TO 4
220 READ T$(I)
230 NEXT I
```

OR CLEAR A RECTANGULAR ARRAY:

```
240 FOR R = 1 TO 4
250 FOR C = 1 TO 3
260 LET B(R,C)= 0
270 NEXT C
280 NEXT R
```

OR PRINT A VECTOR (IN THIS CASE AS A ROW):

```
290 FOR I = 1 TO 4
300 PRINT T$(I);
310 NEXT I
320 PRINT
```

OR PRINT A RECTANGULAR ARRAY (IN THIS CASE BY ROWS):

```
330 FOR R = 1 TO 4
340 FOR C = 1 TO 4
350 PRINT B(R,C);
360 NEXT C
370 PRINT
380 NEXT R
```

OR SCAN A LIST OF ITEMS TO FIND THE LOCATION OF A PARTICULAR ITEM.

```
390 FOR I = 1 TO 4
400 IF T$(I) = "C" THEN 430
410 NEXT I
420 LET I = 0
430 PRINT "LOCATION IS"; I
```

BUT BEWARE OF USING COMPLICATED EXPRESSIONS AS SUBSCRIPTS:

```
440 LET X = B(A↑2/2 , 3)
```

WHAT WOULD HAPPEN IF A↑2/2 TURNED OUT TO BE 3.99999?

☆ SOME *BASICS* WOULD TAKE THE *INTEGRAL PART* OF THE RESULT AND LET X = B(3,3)

☆ OTHER *BASICS* WOULD TAKE THE *NEAREST INTEGER* TO THE RESULT AND LET X = B(4,3)

YOU CAN EASILY TEST WHAT YOUR OWN VERSION OF *BASIC* DOES BY RUNNING THE LITTLE PROGRAM BELOW. BUT YOU SHOULD NOT WRITE PROGRAMS THAT RELY ON ONE PARTICULAR INTERPRETATION. KEEP SUBSCRIPTS SIMPLE AND USE "INT( )" IF THEIR VALUES COULD HAVE FRACTIONAL PARTS.

```
10  DIM    A(2)
20  LET    A(1) = 100
30  LET    A(2) = 200
40  LET    I = 1.99
50  PRINT  A(I)
60  END
```

RIPPLE SORT

AN EXAMPLE TO ILLUSTRATE *SUBSCRIPTED VARIABLES*

SORTING NUMBERS INTO ASCENDING ORDER IS SIMPLE IN CONCEPT BUT SURPRISINGLY DIFFICULT TO ORGANISE WHEN THERE ARE LARGE VOLUMES OF DATA. THE EXAMPLE BELOW USES THE SIMPLEST TECHNIQUE OF ALL — THE *RIPPLE* SORT — WHICH IS ADEQUATE FOR SMALL VOLUMES OF DATA (100 OR SO NUMBERS) STORED AS ARRAYS IN *BASIC*.

A(1)	6.5
A(2)	13.9
A(3)	4.6
A(4)	10.2
A(5)	3.5

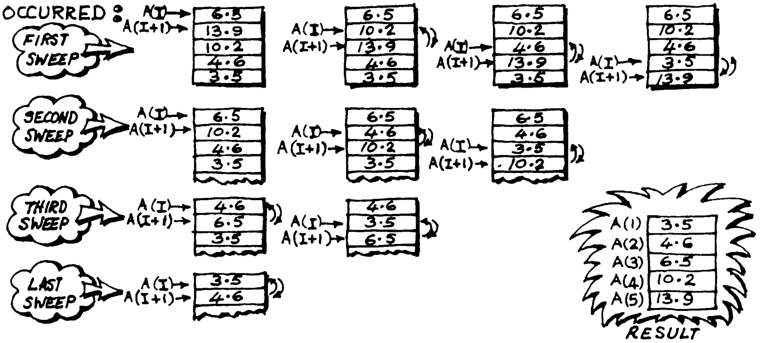
ARRAY A(), A COLUMN VECTOR, IS TO BE SORTED INTO ASCENDING ORDER — HEAVIEST NUMBERS SINKING TO THE BOTTOM. YOU CAN REVERSE THIS ORDER BY REVERSING THE CONDITION IN THE "IF" STATEMENT.

WE START WITH AN "INDEX" I POINTING TO ROW 1; THEN WE ADVANCE I ROW BY ROW. AT EVERY ADVANCE WE LOOK AT THE NUMBER I IS POINTING TO — AND ALSO AT THE NUMBER ONE ROW AHEAD OF I. IF THE FORMER IS GREATER THAN THE LATTER WE SWOP THE TWO NUMBERS.

HAVING FINISHED ONE "SWEEP" OF I WE SWEEP AGAIN — BUT STOP ONE ROW SHORT OF THE PREVIOUS SWEEP BECAUSE THE HEAVIEST NUMBER MUST ALREADY HAVE SUNK TO THE BOTTOM.

WE CONTINUE SWEEPING — EACH SWEEP A ROW SHORTER THAN THE PREVIOUS ONE — UNTIL THERE IS A WHOLE SWEEP WITHOUT A SINGLE SWOP IN IT OR THE LENGTH OF SWEEP IS REDUCED TO NOTHING.

HERE IS THE WHOLE PROCESS: ⟫ SHOWS WHERE A SWOP HAS JUST OCCURRED:

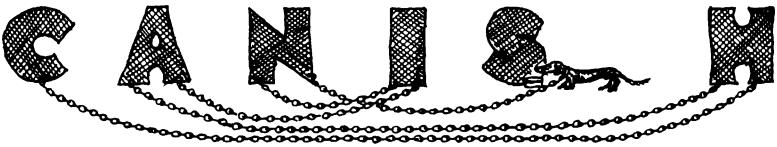


THE PROGRAM BELOW IS DESIGNED TO SORT A COLUMN VECTOR, A(), HAVING N ROWS. THE VECTOR IS FILLED FROM "DATA" STATEMENTS — THE FIRST NUMBER IN THE FIRST "DATA" STATEMENT TELLING THE NUMBER OF NUMBERS TO BE SORTED. THE LOGIC ILLUSTRATED HERE IS USED AGAIN IN A MORE USEFUL WAY ON PAGE 71 WHERE WE AVOID ACTUALLY HAVING TO MOVE THE NUMBERS BEING SORTED.

```
10   REM   RIPPLE SORT; MAX 100 NUMBERS
20   DIM   A(100)
30   DATA   5
40   DATA   6.5, 13.9, 4.6, 10.2, 3.5
50   REM   CONTINUE DATA STATEMENTS AS RQD.
60   REM                                   NUMBER OF
1000  READ  N                              NUMBERS
1010  FOR  I = 1 TO N                      FILL VECTOR
1020  READ  A(I)                           A()
1030  NEXT I
1040  REM
1050  REM
1060  FOR  S = 1 TO N-1                    SWEEPS
1070  LET  M = 0                           INDEX IN
1080  FOR  I = 1 TO N-S                    EACH SWEEP
1090  IF   A(I) <= A(I+1)  THEN  1140
1100  LET  X = A(I)                        DON'T
1110  LET  A(I) = A(I+1)                   SWOP
1120  LET  A(I+1) = X
1130  LET  M = 1
1140  NEXT  I
1150  IF   M = 0  THEN  2000               EARLY
1160  NEXT  S                              EXIT
2000  REM
2010  REM
2020  FOR  I = 1 TO N
2030  PRINT  A(I)
2040  NEXT  I
2050  END
```

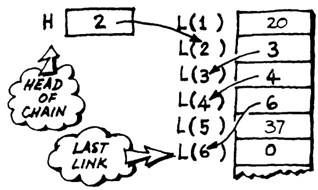
VARIABLE M IS A "MARK" SET ZERO BEFORE EACH SWEEP BUT SET NON-ZERO EVERY TIME THERE IS A SWOP. M IS TESTED AT THE END OF EACH SWEEP AND IF IT SHOWS THERE WERE NO SWOPS THEN CONTROL JUMPS TO AN EARLY EXIT.

THIS TECHNIQUE — AND OTHERS USED IN THE LONGER EXAMPLES IN THIS BOOK — ARE EXPLAINED VERY CLEARLY BY A. COLIN DAY IN "FORTRAN TECHNIQUES" : CAMBRIDGE UNIVERSITY PRESS (1972).



CHAINS ILLUSTRATE THE USEFULNESS OF SUBSCRIPTS. THE MANIPULATION OF CHAINS IS CALLED *LIST PROCESSING*.

THE SIMPLEST KIND OF CHAIN IS ILLUSTRATED BELOW. IT HAS A *HEAD* IN THE FORM OF A SIMPLE VARIABLE, **H**. THIS STORES A *POINTER* POINTING TO THE FIRST ROW OF INFORMATION SOMEWHERE IN ARRAY A(,) ⇔ POINTING ALSO TO A *LINK* CONTAINING ANOTHER POINTER POINTING TO THE *NEXT* ROW OF INFORMATION IN A(,). THE LAST LINK IN THE CHAIN CONTAINS A *ZERO* SAYING " END OF CHAIN ".



	1)	2)	3)
A(1,	6·3	−1	123
A(2,	4·7	0	246
A(3,	20·0	0	468
A(4,	16·2	0	821
A(5,	19·0	−1	333
A(6,	33·0	0	900

THE FOLLOWING PIECE OF PROGRAM WOULD PRINT INFORMATION IN A(,) ORGANISED BY THE CHAIN WITH HEAD **H** ⇔ HOWEVER LONG THE CHAIN.

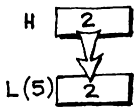
```
155 LET R = H
160 IF R=0 THEN 180
165 PRINT A(R,1); A(R,2); A(R,3)
170 LET R= L(R)        PICK UP NEXT LINK
175 GO TO 160
180 END

RUN

 4·7  0  246
 20  0  468
 16·2  0  821
 33  0  900
```

THE CLEAREST WAY TO DRAW A CHAIN IS TO HOLD THE HEAD IN ONE HAND, THE LAST LINK IN THE OTHER, AND PULL TIGHT. THE CHAIN ILLUSTRATED ABOVE NOW LOOKS LIKE THIS:

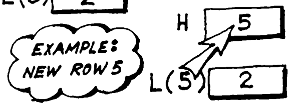
H [2] → L(2) [3] → L(3) [4] → L(4) [6] → L(6) [0]

WE USE THIS MODEL TO EXPLAIN SOME OPERATIONS ON CHAINS.

A NEW ROW OF A(,) MAY BE LINKED INTO THE CHAIN LIKE THIS:

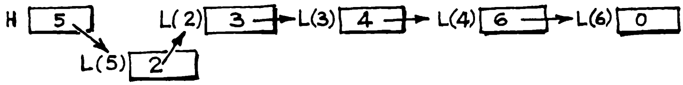


COPY THE CONTENTS OF THE HEAD INTO THE NEW LINK;



COPY THE NEW LINK'S SUBSCRIPT INTO THE HEAD (THUS MAKING THE HEAD POINT TO THE NEW LINK).

RESULT:



THE FOLLOWING SUBROUTINE LINKS ROW N INTO A CHAIN STORED IN VECTOR L( ) AND HEAD IN VARIABLE H:

```
100   REM LINK ROW N TO CHAIN L( ) HEAD H
110   LET L(N) = H
120   LET H=N
130   RETURN
```

SO LINKING ROW 5 TO THE CHAIN (PICTURED ABOVE) CAN BE DONE VERY SIMPLY LIKE THIS:

```
1055  LET N=5
1060  GO SUB 100
1065
```

AND CREATING A NEW CHAIN TO LINK, SAY, THE FIRST 10 ROWS LIKE THIS:

```
2125  LET H=0          <- BEGIN WITH EMPTY CHAIN
2130  FOR N = 1 TO 10
2135  GO SUB 100
2140  NEXT N
```

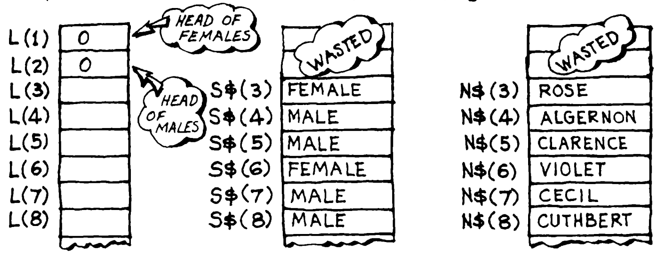
NOTICE THE *LAST* ROW TO BE LINKED TO A CHAIN IN THIS WAY IS THE *FIRST* TO BE PRINTED BY THE ROUTINE OPPOSITE. THUS THE MECHANISM MAY BE USED TO ORGANIZE A *STACK* OF THE KIND DESCRIBED ON PAGE 54. TAKING AN ELEMENT FROM THE TOP OF THE STACK MAY BE DONE LIKE THIS:

```
3260  LET R=H        <- REMEMBER THE ROW OF THE ELEMENT
3265  LET H=L(H)     <- DISCARD TOP LINK
```

CHAINS (CONTINUED)

IT MAKES FOR TIDIER PROGRAMS TO STORE HEADS OF CHAINS IN THE SAME VECTOR AS THE LINKS. THIS WASTES A FEW STORAGE LOCATIONS (AS SHOWN BELOW) BUT YOU MAY REGAIN THE SPACE BY OFFSETTING THE CHAIN FROM ITS INFORMATION AT THE EXPENSE OF MORE COMPLICATED SUBSCRIPTS IF YOU WISH.

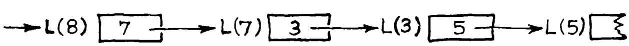
MORE THAN ONE CHAIN CAN EXIST IN THE SAME VECTOR AS LONG AS THE ROWS BEING LINKED ARE MUTUALLY EXCLUSIVE (*i.e.* NO LINK CAN BE IN MORE THAN ONE CHAIN). THE SUBROUTINE BELOW LINKS WOMEN INTO ONE CHAIN AND MEN INTO ANOTHER. THE HEADS OF BOTH CHAINS ARE AT THE TOP OF THE VECTOR STORING BOTH CHAINS.



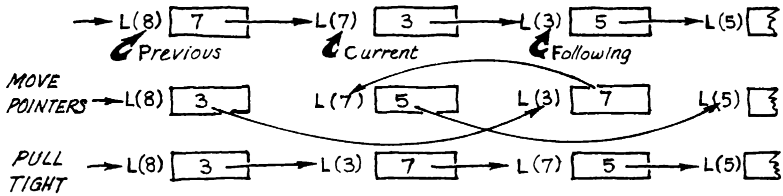

```
1000 REM  LINK INTERTWINED CHAINS; N PEOPLE
1010 LET  L(1)=0
1020 LET  L(2)=0
1030 FOR  I=3 TO N+2
1040 LET  Q=1
1050 IF   S$(I)= "FEMALE" THEN 1070
1060 LET  Q=2
1070 LET  L(I) = L(Q)
1080 LET  L(Q) = I
1090 NEXT I
1100 RETURN
```

NOT RIGOROUSLY CHECKED: ANYONE NOT DECLARED FEMALE IS TREATED AS MALE

IN THE SORTING PROGRAM ON PAGE 66 WE EXCHANGED ITEMS OF DATA. WITH CHAINED LISTS, HOWEVER, IT IS ONLY NECESSARY TO EXCHANGE *LINKS* WHEN SORTING. CONSIDER THIS SHORT LENGTH OF CHAIN:



TO *EFFECTIVELY* SWOP ROWS 7 & 3 OF THE ARRAY ASSOCIATED WITH THIS CHAIN YOU NEED ONLY SHUNT THREE POINTERS AROUND THE LINKS AS ILLUSTRATED OPPOSITE.



THE SUBROUTINE BELOW USES THE SAME LOGIC AS THE PROGRAM ON PAGE 67 — THE *RIPPLE* SORT — BUT WHENEVER IT HAS TO SWOP ROWS IT MOVES POINTERS IN THE MANNER ILLUSTRATED ABOVE. THE LOGIC FOR THIS IS ON LINES 2100 TO 2130, WHERE:

- P IS A SUBSCRIPT FOR THE *PREVIOUS* LINK,
- C IS A SUBSCRIPT FOR THE *CURRENT* LINK,
- F IS A SUBSCRIPT FOR THE *FOLLOWING* LINK,

ALL AS SHOWN IN THE PICTURE ABOVE. AFTER A SWOP, C IS NO LONGER THE CURRENT SUBSCRIPT; IT IS ALTERED AT LINE 2140.

```
2000 REM RIPPLE SORT. CHAIN L( ); HEAD L(Z);
2005 REM NUMBER OF ROWS N(Z); COLUMN K OF A(,).
2010 FOR S=1 TO N(Z)-1
2020 LET M=0
2030 LET C=Z              HEAD OF CHAIN IS L(Z)
2040 FOR I=1 TO N(Z)-S
2050 LET P=C              NEW "PREVIOUS" = OLD "CURRENT"
2060 LET C=L(C)           CLIMB DOWN TO NEXT LINK
2070 LET F=L(C)           LOOK AHEAD TO FOLLOWING LINK
2080 IF A(C,K) <= A(F,K) THEN 2150
                          SORT ON THE Kth COLUMN OF A(,)
                          DON'T SWOP
2090 LET M=1
2100 LET X=L(P)           SEE PICTURE ABOVE
2110 LET L(P)=L(C)
2120 LET L(C)=L(F)
2130 LET L(F)=X
2140 LET C=F
2150 NEXT I
2160 IF M=0 THEN 2180     EARLY EXIT
2170 NEXT S
2180 RETURN
```

OTHER DIFFERENCES FROM THE PROGRAM ON PAGE 67 ARE NOT CONCERNED WITH THE LOGIC OF SORTING. THE ROUTINE ABOVE CAN USE *ANY* CHAIN STORED IN L( ) BEING TOLD A VALUE OF Z: THE HEAD OF THE REQUIRED CHAIN IS THEN L(Z) AND THE NUMBER OF ITEMS IS IN N(Z). FURTHERMORE THE ROUTINE ABOVE CAN SORT *ANY* COLUMN OF ARRAY A(,) BEING TOLD THE NUMBER OF THAT COLUMN IN K.

BREAKDOWNS

AN *EXAMPLE* USING THE SIMPLE LIST PROCESSING TECHNIQUES JUST DESCRIBED.

THE TYPICAL "MANAGEMENT REPORTING" PROGRAM DEALS WITH "POPULATIONS BROKEN DOWN BY AGE, RELIGION AND SEX". THE FOLLOWING PROGRAM IS A GHASTLY PARODY OF THE REAL THING BUT SERVES TO ILLUSTRATE A FEW OF THE TECHNIQUES AT THE HEART OF BUSINESS DATA PROCESSING. THE PROGRAM SORTS DIFFERENT COLUMNS OF NUMBERS. IT IS LEFT AS AN EXERCISE FOR THE READER TO EXTEND THE PROGRAM TO SORT NAMES ALPHABETICALLY (SEE PAGE 41 ON THIS).

THIS PROGRAM CALLS THE TWO SUBROUTINES GIVEN ON THE PREVIOUS DOUBLE PAGE. TO USE THE PROGRAM YOU TYPE THE NAME, SEX, DEPARTMENT NUMBER, AGE & SALARY OF EACH MEMBER OF STAFF OF A DEPARTMENT STORE. THE PROGRAM THEN PRINTS THREE MANAGEMENT REPORTS EACH OF WHICH DEALS SEPARATELY WITH THE SEXES. THE FIRST REPORT TABULATES THE INPUT DATA ORDERED BY DEPARTMENT NUMBER, THE SECOND ORDERED BY AGE OF EMPLOYEE, THE THIRD BY SALARY. IN ALL THREE REPORTS THE "ORDERING" COLUMN IS KEPT NEXT TO THE COLUMN OF NAMES.

AN IMPORTANT THING TO NOTICE ABOUT THIS PROGRAM IS THAT THE ORIGINAL INPUT DATA ARE NEVER MOVED. ORGANIZATION IS BY SHUNTING POINTERS ABOUT IN A SINGLE LIST OF POINTERS.

```
10 PRINT "DEPARTMENT STORE:  STAFF ANALYSIS"
20 DIM N(2), L$(100), N$(100), M$(100), S$(100), A(100,3), T$(2), R$(3)
30 DATA "FEMALE", "MALE", "DEPARTMENT", "AGE", "SALARY"
40 READ T$(1),   T$(2),  R$(1),      R$(2),   R$(3)
50 DEF  FNC(Y)=Y-3*INT(Y/4)
60 REM  FNC CYCLES 1,2,3,1,2  AS Y GOES 1 TO 5
70 PRINT "HOW MANY STAFF"
80 INPUT  N                          NUMBER OF STAFF
90 PRINT "FIRSTNAME,LASTNAME,   SEX,   DEPT.,    AGE, SALARY"
100 LET  N(2)=0
110   FOR I = 3 TO N+2
120   INPUT   N$(I),   M$(I),   S$(I),   A(I,1),  A(I,2),  A(I,3)
130   IF   S$(I) = T$(1)   THEN  150
140   LET   N(2)=N(2)+1              COUNT THE NUMBER OF MEN
150   NEXT I
160 LET N(1)= N - N(2)               NUMBER OF WOMEN
170 REM   INPUT COMPLETE
```

```
180 REM    BEGIN ANALYSIS            CREATE TWO CHAINS; FEMALE & MALE
190 GO SUB  1000
200 FOR  K = 1  TO  3                CYCLE 3 COLUMNS OF A(,) TO GIVE 3 REPORTS
210 PRINT                            SPACE
220 PRINT "REPORT"; K; "ORDERED BY "; R$(K)
230 PRINT
240   FOR  Z = 1  TO  2              CYCLE WOMEN THEN MEN
250   GO SUB  2000                   SORT ON COLUMN K OF A(,)
260   PRINT                          SPACE
270   PRINT  T$(Z); " STAFF"
280   PRINT  "NAME" , , R$(K), R$( FNC(K+1) ), R$(  FNC(K+2) )
290   LET  R=L(Z)                    HEAD OF CHAIN
300      IF  R = 0  THEN  340
310      PRINT  N$(R), M$(R), A(R,K), A(R, FNC(K+1)), A(R, FNC(K+2) )
320      LET  R=L(R)                 NEXT LINK
330      GO TO  300
340   NEXT Z
350 NEXT K                           DON'T FALL THROUGH SUBROUTINES
360 GO TO 9999
     INSERT SUBROUTINES 1000 & 2000 HERE
9999 END

RUN

DEPARTMENT STORE:  STAFF ANALYSIS
HOW MANY STAFF
? 6
FIRSTNAME,LASTNAME,     SEX,     DEPT.,     AGE,   SALARY
? ROSE STAGG    FEMALE       6        21      2800
? ALGERNON SWEET   MALE    6       23       3750
? CLARENCE PETTY    MALE     7        22      3750
? VIOLET BUCK     FEMALE     6     66      2000
? CECIL WILTING    MALE      7      18      4000
? CUTHBERT MACQUEEN MALE        5      70    6000

REPORT 1 ORDERED BY DEPARTMENT

FEMALE STAFF                           THIS BECOMES THE FIRST COLUMN HEADING IN REPORT 2    DITTO: REPORT 3
NAME                     DEPARTMENT     AGE          SALARY
VIOLET       BUCK         6             66           2000
ROSE         STAGG        6             21           2800
MALE STAFF
NAME                     DEPARTMENT     AGE          SALARY
CUTHBERT     MACQUEEN     5             70           6000
ALGERNON     SWEET        6             23           3750
CECIL        WILTING      7             18           4000
CLARENCE     PETTY        7             22           3750

REPORT 2 ORDERED BY AGE     etc. etc.
```

5

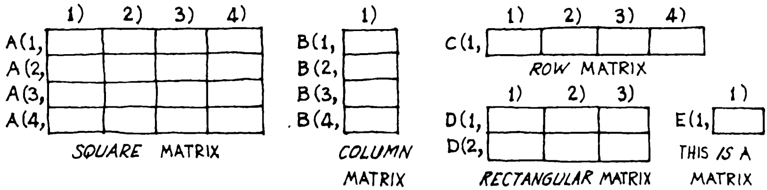
MATRICES

MATRICES†

DON'T RUN AWAY — YOU DON'T HAVE TO KNOW MATRIX ALGEBRA TO FIND "MAT" STATEMENTS USEFUL.

IN *BASIC* A MATRIX IS SIMPLY A RECTANGULAR ARRAY OF SUBSCRIPTED VARIABLES:

```
10 DIM A(4,4), B(4,1), C(1,4), D(2,3), E(1,1)
```



AND THERE ARE ABOUT 12 "MAT" STATEMENTS IN MOST *BASICS* WITH WHICH YOU CAN *MANIPULATE* SUCH ARRAYS.

BUT WATCH OUT FOR THE FOLLOWING:

SOME *BASICS* ALLOW "MAT" STATEMENTS TO BE USED ON *ONE*-DIMENSIONAL ARRAYS BUT OTHERS DON'T. SO ALWAYS MAKE *TWO*-DIMENSIONAL ARRAYS WHEN YOU INTEND TO USE "MAT" STATEMENTS — EVEN WHEN ONE OF THE DIMENSIONS IS UNITY (AS IN B(,), C(,) & E(,) ABOVE).

DON'T OMIT "DIM" STATEMENTS FOR ARRAYS EVEN THOUGH MOST *BASICS* ALLOW SUCH OMISSION WHEN DIMENSIONS ARE 10 OR LESS (SEE PAGE 62).

SOME *BASICS* ALLOW SUBSCRIPTS OF ZERO, BUT IN SPITE OF THIS THEIR "MAT" STATEMENTS **IGNORE** THE ZEROth ROW & ZEROth COLUMN (THUS SUPPORTING THE EXHORTATION ON PAGE 63 NEVER TO USE ZERO SUBSCRIPTS). JUST IN CASE YOUR VERSION *DOES* ALLOW ZERO SUBSCRIPTS — AND YOU CAN'T BE CERTAIN FROM ITS USER'S MANUAL WHETHER "MAT" STATEMENTS FOLLOW SUIT — RUN THIS LITTLE PROGRAM.

```
10 DIM A(1,1)
20 LET A(0,0)=0
30 MAT A = CON
40 PRINT A(0,0)
50 END
RUN
 0        GOOD!
```

IF IT SHOULD PRINT 1 RATHER THAN 0 THEN PROBABLY ALL YOUR "MAT" STATEMENTS TAKE ACCOUNT OF THE ZEROth ROW & COLUMN — AN UNUSUAL *BASIC* SYSTEM.

† matrix, *mā'triks*, or *mat'riks*, *n.* (math.) a rectangular array of quantities or symbols: *pl* ma'trices (*-tris-ēz*, or *iz*) [L *mātrix, icis*, a breeding animal, later, the womb - *mater*, mother]

MATRIX INSTRUCTIONS BEGIN WITH THE WORD "MAT". TWELVE OF THEM ARE LISTED BELOW AND DESCRIBED ON SUCCEEDING PAGES. TERMS LIKE "TRANSPOSITION", "MATRIX MULTIPLICATION", AND "INVERSION" ARE EXPLAINED SO THAT THOSE WHO HAVE NEVER MET MATRIX ALGEBRA MAY UNDERSTAND AND USE THE ASSOCIATED INSTRUCTIONS.

		PAGE
MAT A = B	FOR MAKING ARRAY A(,) THE SAME AS B(,).	78
MAT A = B ± C	FOR MAKING ELEMENTS OF ARRAY A(,) THE SUM OR DIFFERENCE OF CORRESPONDING ELEMENTS OF B(,) AND C(,).	80
MAT A = (N) * B	FOR MAKING ELEMENTS OF ARRAY A(,) "N" TIMES CORRESPONDING ELEMENTS OF B(,) WHERE "N" IS A NUMBER — NOT A MATRIX.	82
MAT A = TRN(B)	FOR MAKING THE *ROWS* OF ARRAY A(,) THE SAME AS THE *COLUMNS* OF ARRAY B(,).	84
MAT A = ZER	FOR MAKING ALL ELEMENTS OF ARRAY A(,) ZERO.	86
MAT A = CON	FOR MAKING ALL ELEMENTS OF ARRAY A(,) UNITY.	87
MAT A = IDN	FOR MAKING *SQUARE* ARRAY A(,) INTO AN *IDENTITY* MATRIX — 1'S ON THE DIAGONAL AND 0'S OFF THE DIAGONAL.	87
MAT R = A * B	FOR MAKING ARRAY R(,) THE MATRIX PRODUCT OF A(,) AND B(,) BY MATRIX MULTIPLICATION.	88
MAT A = INV(B)	FOR MAKING ARRAY A(,) THE INVERSE OF THE MATRIX IN *SQUARE* ARRAY B(,).	92
MAT READ A, B, C	FOR READING COMPLETE ARRAYS FROM "DATA" STATEMENTS.	94
MAT INPUT A, B, C	FOR DEMANDING COMPLETE ARRAYS FROM A SOURCE OUTSIDE THE PROGRAM.	96
MAT PRINT A, B, C	FOR PRINTING COMPLETE ARRAYS.	98

ANY LETTERS IN ALL THESE 'MAT' INSTRUCTIONS; NOT JUST A, B, C

FOR EVERY "MAT" INSTRUCTION THIS BOOK GIVES A CORRESPONDING ROUTINE IN ELEMENTARY *BASIC* USING NESTED LOOPS. IN ANY NEST OF LOOPS THE VARIABLE CONTROLLING THE INNERMOST LOOP VARIES FASTEST. IF *BASIC* STORES ARRAYS BY COLUMNS THEN IT IS MOST EFFICIENT TO MAKE THE *ROW* SUBSCRIPT VARY FASTEST & CONVERSELY IF *BASIC* STORES ARRAYS BY ROWS THEN IT IS BETTER TO MAKE THE *COLUMN* SUBSCRIPT VARY FASTEST. IT HAPPENS THAT SOME *BASICS* STORE ARRAYS BY COLUMNS; OTHERS BY ROWS; SO DON'T LOOK FOR SIGNIFICANCE IN THE CHOICE OF ROW & COLUMN SUBSCRIPTS IN THIS BOOK.

MAT A = B

THIS INSTRUCTION MAKES A COPY OF A COMPLETE ARRAY.

```
10  DIM  A(3,4), B(3,4), C(2,3)
```

	1)	2)	3)	4)
A(1,				
A(2,				
A(3,				

	1)	2)	3)	4)
B(1,	5	−9.6	2.5	7.91
B(2,	6.3	0	1	2.44
B(3,	7.2	3.7	−1	8.86

	1)	2)	3)
C(1,	235	198	137
C(2,	642	856	705

SUPPOSE YOU WANT ARRAY A(,) TO CONTAIN THE VALUES NOW CONTAINED IN ARRAY B(,). YOU CAN ACHIEVE THIS FAIRLY SIMPLY BY COPYING FROM B(,) TO A(,) ELEMENT BY ELEMENT LIKE THIS:

```
200  FOR C = 1 TO 4        <- CYCLE COLUMNS
210  FOR R = 1 TO 3        <- CYCLE ROWS
220  LET A(R,C) = B(R,C)
230  NEXT R
240  NEXT C
```

BUT YOU COULD DO THE WHOLE THING WITH A SINGLE "MAT" INSTRUCTION LIKE THIS:

```
100  MAT  A = B
```

NOTICE THAT A & B ON LINE 100 HAVE NOTHING WHATEVER TO DO WITH SIMPLE VARIABLES A & B. THE WORD "MAT" TELLS *BASIC* YOU MEAN *ARRAYS* A(,) & B(,).

WITH THE ARRAYS PICTURED ABOVE IT WOULD BE A MISTAKE TO HAVE LINE 110 AS SHOWN BELOW; B(,) IS TOO BIG TO FIT INSIDE C(,). BUT LINE 120 *IS* ALLOWED. IT HAS THE EFFECT OF *ALTERING* THE DIMENSIONS OF B(,) TO 2 ROWS AND 3 COLUMNS: 2 & 3 ARE NOW ITS **CURRENT DIMENSIONS**

```
110  MAT  C=B
120  MAT  B=C
```

SHRINKS

B(2,4) NO LONGER EXISTS

	1)	2)	3)
B(1,	235	198	137
B(2,	642	856	705

WHICH MAY BE ADJUSTED LATER BY OTHER "MAT" INSTRUCTIONS PROVIDED THAT THEY NEVER EXCEED THOSE IN ITS ORIGINAL "DIM" STATEMENT.

RE-DIMENSIONING

THIS APPLIES TO NEARLY ALL THE "MAT" INSTRUCTIONS.

AFTER LINE 120 OPPOSITE, ARRAY B(,) IS *RE-DIMENSIONED* TO BE THE SAME AS ARRAY C(,). IT WOULD NOW BE WRONG TO HAVE:

```
130   LET   B(2,4) = 13
```

BECAUSE B(2,4) HAS CEASED TO EXIST. IN SPITE OF THIS SOME *BASICS* WOULD FAIL TO REPORT AN ERROR AND WOULD DO SOMETHING WITH UNPREDICTABLE RESULTS THE 13 APPEARING PHANTOM-LIKE IN SOME OTHER LOCATION.

IT IS STILL ALLOWABLE TO HAVE:

```
140   MAT   B = A
```

EVEN THOUGH A(,) STILL HAS 3 ROWS & 4 COLUMNS WHEREAS B(,) CURRENTLY HAS ONLY 2 ROWS & 3 COLUMNS. A "MAT" INSTRUCTION (UNLIKE THE ORDINARY "LET" INSTRUCTION) RE-DIMENSIONS B(,) GIVING IT CURRENT DIMENSIONS OF 3 ROWS & 4 COLUMNS *ONCE AGAIN*.

IN GENERAL *BASIC* RE-DIMENSIONS AN ARRAY ON THE LEFT OF THE EQUALS SIGN ACCORDING TO CURRENT DIMENSIONS OF ARRAYS ON THE RIGHT *AS LONG AS THE ORIGINAL SIZE GIVEN IN THE* "DIM" *STATEMENT IS NOT EXCEEDED*. (THAT IS WHY LINE 110 OPPOSITE IS WRONG BUT 140 ABOVE IS CORRECT.)

THERE IS, HOWEVER, A COMPLICATION: MOST *BASICS* SEEM TO INTERPRET "*ORIGINAL SIZE*" AS MEANING THE TOTAL NUMBER OF ELEMENTS IN THE ORIGINAL ARRAY; THUS IF P(1,16) APPEARED IN THE "DIM" STATEMENT, P(,) COULD BECOME, THROUGH RE-DIMENSIONING, A SQUARE ARRAY OF FOUR ROWS AND FOUR COLUMNS. THIS IS NOT NICE. IT IS BETTER AND SAFER TO CONSIDER EACH DIMENSION AS AN INDIVIDUAL LIMIT OF RE-DIMENSIONING THUS P(1,16) IN THE ORIGINAL "DIM" STATEMENT MAY ATTAIN ANY NUMBER OF COLUMNS UP TO 16, BUT NEVER MORE THAN ONE ROW. IF YOU *PLAN* TO HAVE P(,) CHANGE FROM ONE ROW OF 16 ELEMENTS TO FOUR ROWS OF 4 ELEMENTS THEN YOU SHOULD DECLARE P(4,16) IN THE "DIM" STATEMENT.

MAT A = B ± C

```
10 DIM   A(3,2), B(3,2), C(3,2), D(2,3), E(3,3)
```

	1)	2)
A(1,	4·3	0
A(2,	8·5	4
A(3,	9·4	4·3

	1)	2)
B(1,	1·5	−2·7
B(2,	3·6	7·8
B(3,	8·4	4·3

	1)	2)
C(1,	2·8	2·7
C(2,	4·9	−3·8
C(3,	1	0

	1)	2)	3)
D(1,			
D(2,			

	1)	2)	3)
E(1,			
E(2,			
E(3,			

SUPPOSE YOU WANT EACH ELEMENT OF ARRAY A(,) TO BE THE SUM (OR DIFFERENCE) OF THE TWO CORRESPONDING ELEMENTS IN ARRAYS B(,) AND C(,). YOU COULD ACHIEVE THIS AS FOLLOWS:

```
200   FOR   C = 1 TO 2
210   FOR   R = 1 TO 3
220   LET A(R,C) = B(R,C) + C(R,C)
230   NEXT  R
240   NEXT  C
```

MINUS SIGN IF THE DIFFERENCE IS WANTED

BUT YOU COULD DO THE WHOLE THING WITH A SINGLE "MAT" INSTRUCTION LIKE THIS:

```
100   MAT   A = B + C
```

OR MINUS

ARRAYS B(,) AND C(,) WOULD BE UNDISTURBED: ARRAY A(,) WOULD END UP AS SHOWN AT THE TOP OF THIS PAGE.

NOTICE THAT A, B & C ON LINE 100 HAVE NOTHING TO DO WITH THE ORDINARY VARIABLES A, B & C: THE WORD "MAT" TELLS *BASIC* YOU MEAN *ARRAYS* A(,), B(,) & C(,).

IF THE *CURRENT* DIMENSIONS OF THE TWO ARRAYS NAMED ON THE RIGHT OF THE EQUALS SIGN ARE NOT IDENTICAL THEN *BASIC* REFUSES TO OBEY THIS INSTRUCTION.

```
110   MAT   A = B + D
```

DIM B(3,2) VS D(2,3)

THE ARRAY NAMED ON THE LEFT OF THE EQUALS SIGN MUST HAVE DIMENSIONS AT LEAST AS GREAT AS THE *CURRENT* DIMENSIONS OF THE ARRAYS NAMED ON THE RIGHT. THUS LINE 130 BELOW IS WRONG; LINE 140 IS ALLOWED BUT WOULD CAUSE *BASIC* TO RE-DIMENSION ARRAY E(,) SO THAT IT HAD 3 ROWS AND 2 COLUMNS; IT WOULD THEN BE A MISTAKE TO REFER TO E(3,3). IMPLICATIONS OF RE-DIMENSIONING ARE DISCUSSED ON PAGE 79.

```
130 MAT D = B + C
140 MAT E = B + C
150 LET E (3 ,3 ) = 13
```

IN SOME (BUT *NOT* ALL) *BASICS* YOU ARE ALLOWED TO HAVE THE NAME OF AN ARRAY ON BOTH SIDES OF THE EQUALS SIGN; FOR THE SAKE OF "PORTABILITY" DON'T DO IT.

```
160 MAT A = A + A
170 MAT A = A - C
180 MAT A = C - A
```

DON'T RISK IT

THE FORM OF THIS INSTRUCTION MAY NOT BE VARIED. DON'T TRY ADDING EXTRA SIGNS AND LETTERS.

```
190 MAT A = -B + C
200 MAT A = B + C + F
210 MAT A = -B
```

MAT A = C-B

MAT X = B+C
MAT A = X+F

MAT A = (-1)*B
SEE OVERLEAF

MAT A = ("SCALAR" EXPRESSION) * B

```
10  DIM  A(3,2), B(3,2), C(4,3), D(2,2)
```

	1)	2)
A(1,	15.6	4.5
A(2,	−9	0
A(3,	6	−6

	1)	2)
B(1,	5.2	1.5
B(2,	−3	0
B(3,	2	−2

	1)	2)	3)
C(1,			
C(2,			
C(3,			
C(4,			

	1)	2)
D(1,		
D(2,		

SUPPOSE YOU WANT EVERY ELEMENT OF ARRAY A(,) TO BE THREE TIMES THE VALUE OF THE CORRESPONDING ELEMENT IN ARRAY B(,). YOU CAN ACHIEVE THIS FAIRLY SIMPLY AS FOLLOWS:

```
200  FOR  C = 1  TO  2
210  FOR  R = 1  TO  3
220  LET  A(R,C) = 3.0*B(R,C)
230  NEXT  R
240  NEXT  C
```

BUT YOU COULD DO THE WHOLE THING WITH A SINGLE "MAT" STATEMENT LIKE THIS:

```
100  MAT  A = (3.0)*B
```

ARRAY B(,) WOULD REMAIN UNDISTURBED AND A(,) WOULD NOW BE AS SHOWN AT THE TOP OF THIS PAGE. EVERY ELEMENT HAS BEEN SCALED BY THE *SCALAR* (*i.e. NON*-VECTOR *or NON*-MATRIX) EXPRESSION IN BRACKETS.

NOTICE THAT A & B ON LINE 100 HAVE NOTHING TO DO WITH THE SIMPLE VARIABLES A & B; THE WORD "MAT" TELLS *BASIC* YOU MEAN *ARRAYS* A(,) & B(,). BUT *INSIDE* THE BRACKETS A & B *WOULD* BE SIMPLE VARIABLES: LINE 130 BELOW WOULD HAVE EXACTLY THE SAME EFFECT AS LINE 100 ABOVE; (A/B) REPRESENTS THE SCALAR QUANTITY (3.0).

```
110  LET  A = 6
120  LET  B = 2
130  MAT  A = (A/B)*B
```

THE ARRAY NAMED ON THE LEFT OF THE EQUALS SIGN MUST HAVE DIMENSIONS IN THE "DIM" STATEMENT AT LEAST AS BIG AS THE *CURRENT* DIMENSIONS OF THE ARRAY NAMED ON THE RIGHT. THUS LINE 140 BELOW IS WRONG: LINE 150 IS ALLOWED BUT WOULD CAUSE *BASIC* TO RE-DIMENSION ARRAY C(,) SO THAT IT HAD 3 ROWS AND 2 COLUMNS: IT WOULD THEN BE A MISTAKE TO REFER TO C(4,2). IMPLICATIONS OF RE-DIMENSIONING ARE DISCUSSED ON PAGE 79.

```
140   MAT   D = (0.5) * B
150   MAT   C = (-1) * B
160   LET   C(4,2) = 13
```

IN SOME (*NOT* ALL) *BASICS* YOU ARE ALLOWED TO NAME THE SAME ARRAY ON BOTH SIDES OF THE EQUALS SIGN: FOR THE SAKE OF "PORTABILITY" DON'T DO IT:

```
170   MAT   A = (-X) * A          DON'T DO IT!
```

THE EXPRESSION IN BRACKETS MAY BE AS COMPLICATED AS YOU LIKE AS LONG AS IT REPRESENTS A SINGLE SCALAR VALUE:

```
180   MAT   A = (-X+SQR(3*B(2*I,J))) * B
```

THE FORM OF THIS INSTRUCTION IS STRICTLY AS SHOWN IN THE HEADING OPPOSITE. SOME ERRORS OF FORM ARE ILLUSTRATED BELOW:

```
185   LET   X = 3                  THIS IS THE FORM FOR "MATRIX
190   MAT   A = X * B              MULTIPLICATION. SEE PAGE 88
192   MAT   A = -(X) * B           MAT A=(-X)*B
194   MAT   A = (X) * (Y) * B      MAT A=(X*Y)*B
196   MAT   A = B * (X)            MAT A=(X)*B
```

MAT A = TRN(B)

```
10  DIM  A(3,2), B(2,3), C(3,3), D(2,2)
```

	1)	2)
A(1,	4·2	−3·8
A(2,	15·6	8·7
A(3,	0	−4

	1)	2)	3)
B(1,	4·2	15·6	0
B(2,	−3·8	8·7	−4

	1)	2)	3)
C(1,			
C(2,			
C(3,			

	1)	2)
D(1,		
D(2,		

SUPPOSE YOU WANT THE *ROWS* OF ARRAY A(,) TO BE THE SAME AS THE *COLUMNS* OF ARRAY B(,) IN OTHER WORDS YOU WANT A(,) TO BE THE *TRANSPOSE* OF B(,). YOU COULD COPY THE ELEMENTS ONE BY ONE LIKE THIS:

```
200  FOR  I = 1  TO  2
210  FOR  J = 1  TO  3
220  LET  A(J,I) = B(I,J)
230  NEXT J
240  NEXT I
```

NOTE THE POSITIONS OF SUBSCRIPTS: (J,I) & (I,J)

BUT YOU COULD DO THE WHOLE THING WITH A SINGLE "MAT" INSTRUCTION LIKE THIS:

```
100  MAT  A = TRN(B)
```

ARRAY B(,) WOULD BE UNDISTURBED; ARRAY A(,) WOULD END UP AS SHOWN AT THE TOP OF THIS PAGE.

NOTICE THAT A & B ON LINE 100 HAVE NOTHING TO DO WITH THE SIMPLE VARIABLES A & B; THE WORD "MAT" TELLS *BASIC* YOU MEAN *ARRAYS* A(,) & B(,).

THE ARRAY NAMED ON THE LEFT OF THE EQUALS SIGN MUST HAVE DIMENSIONS IN ITS "DIM" STATEMENT AT LEAST AS BIG AS THE *CURRENT* DIMENSIONS OF THE ARRAY NAMED ON THE RIGHT. THUS LINE 110 OPPOSITE IS WRONG; LINE 120 IS ALLOWED BUT WOULD CAUSE *BASIC* TO RE-DIMENSION ARRAY C(,) SO THAT IT HAD *THREE* ROWS AND *TWO* COLUMNS (NB. NOT 2 ROWS & 3 COLUMNS) AND IT WOULD THEN BE A MISTAKE TO REFER TO C(3,3).

IMPLICATIONS OF RE-DIMENSIONING ARE DISCUSSED ON PAGE 79.

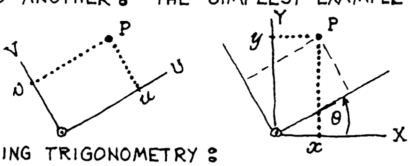
```
110  MAT  D  = TRN(B)
120  MAT  C  = TRN(B)
130  LET  C(3,3)  =  13
```

YOU MAY NOT NAME THE SAME ARRAY ON BOTH SIDES OF THE EQUALS SIGN: IN OTHER WORDS YOU MAY NOT TRANSPOSE A MATRIX ON TOP OF ITSELF:

```
140  MAT  B  =  TRN(B)
```

BUT SOME *BASICS* DO ALLOW THIS. AS AN EXERCISE IT MIGHT AMUSE YOU TO WRITE A ROUTINE FOR REPLACING AN ARRAY BY THE TRANSPOSE OF ITSELF BUT WITHOUT COPYING IT FIRST TO SOME OTHER ARRAY (IN OTHER WORDS YOU SHOULD TRANSPOSE THE ARRAY "IN-SITU"). IT IS TRICKY BUT NOT IMPOSSIBLE.

TRANSPOSITION IS A USEFUL OPERATION IN MATRIX ALGEBRA: IN PARTICULAR FOR TRANSFORMING COORDINATES FROM ONE SET OF AXES TO ANOTHER. THE SIMPLEST EXAMPLE OF THIS IS ILLUSTRATED BELOW.



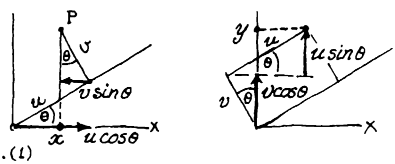
THE COORDINATES OF POINT **P** RELATIVE TO U & V ARE u & v RESPECTIVELY. WHAT ARE THE COORDINATES OF **P** RELATIVE TO AXES X & Y ?

USING TRIGONOMETRY:

$$x = u\cos\theta - v\sin\theta$$
$$y = u\sin\theta + v\cos\theta$$

WHICH MAY BE WRITTEN IN MATRIX FORM AS BELOW:

$$\begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} u \\ v \end{bmatrix} \quad \ldots(1)$$



ALSO USING TRIGONOMETRY IT IS JUST AS SIMPLE TO FIND A PAIR OF EQUATIONS YIELDING u AND v IN TERMS OF x AND y:

$$\begin{bmatrix} u \\ v \end{bmatrix} = \begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} \quad \ldots(2)$$

NOTICE THAT EACH OF THESE SQUARE MATRICES IS THE TRANSPOSE OF THE OTHER.

IT IS GENERALLY TRUE OF ORTHOGONAL AXIS TRANSFORMATIONS THAT TO REVERSE THE TRANSFORMATION YOU SIMPLY *TRANSPOSE* THE TRANSFORMING MATRIX. IN TEXT BOOKS MATRICES ARE OFTEN INDICATED BY LETTERS IN BOLD TYPE AND TRANSPOSITION BY A *PRIME*. THE TWO EQUATIONS ABOVE MIGHT BE SHOWN AS: $\mathbf{X}=\mathbf{T}\mathbf{U}$ AND $\mathbf{U}=\mathbf{T}'\mathbf{X}$.

MAT A = ZER

```
10  DIM  A(3,4) , B(2,3)
```

	1)	2)	3)	4)
A(1,	0	0	0	0
A(2,	0	0	0	0
A(3,	0	0	0	0

	1)	2)	3)
B(1,	1	1	1
B(2,	1	1	1

YOU MAY MAKE ALL ELEMENTS OF AN ARRAY ZERO LIKE THIS:

```
200  FOR   R = 1 TO 3
210  FOR   C = 1 TO 4
220  LET   A(R,C) = 0
230  NEXT  C
240  NEXT  R
```

BUT YOU COULD DO THE WHOLE THING WITH A SINGLE "MAT" INSTRUCTION LIKE THIS:

```
100  MAT  A = ZER
```

WHERE "ZER" IS SIMPLY A WORD SHORT FOR ZERO, AND LETTER A HAS NOTHING TO DO WITH THE SIMPLE VARIABLE A. THE WORD "MAT" TELLS *BASIC* YOU MEAN ARRAY A(,).

TAKE CARE WITH THIS INSTRUCTION AND WITH "CON" AND "IDN" DESCRIBED BELOW. THE ARRAY NAMED ON THE LEFT OF THE EQUALS SIGN IS ASSUMED BY SOME *BASICS* TO RETAIN ITS *CURRENT* DIMENSIONS WHICH MAY BE SMALLER THAN THOSE IN ITS "DIM" STATEMENT. SO UNLESS THIS IS THE VERY FIRST "MAT" INSTRUCTION TO BE OBEYED IT IS SAFER TO USE THE ALTERNATIVE FORM:

EXPRESSIONS ALLOWED HERE

```
110  MAT  A = ZER(2,3)
```

WHICH HAS THE EFFECT OF RE-DIMENSIONING THE ARRAY NAMED ON THE LEFT OF THE EQUALS SIGN AS WELL AS SETTING ITS ELEMENTS TO ZERO. IMPLICATIONS OF RE-DIMENSIONING ARE DISCUSSED ON PAGE 79. IF *YOU* DO USE EXPRESSIONS FOR DIMENSIONS, MAKE CERTAIN (PERHAPS USING "INT") THAT *YOUR* EXPRESSIONS YIELD INTEGRAL RESULTS. SOME *BASICS* USE THE *NEAREST* INTEGER TO THE RESULT BUT OTHERS TAKE THE *INTEGRAL PART* OF THE RESULT.

MAT A = CON

THE ONLY DIFFERENCE BETWEEN THIS INSTRUCTION AND "MAT A=ZER" IS THAT THE RESULTING ARRAY IS FULL OF 1'S RATHER THAN 0'S.

```
120   MAT   B  =   CON(2,3)
```

"CON" IS SHORT FOR *CONSTANT*. YOU CAN SET ALL ELEMENTS TO ANY CONSTANT IN TWO "MAT" INSTRUCTIONS.

```
130   MAT   A  =   CON (2,3)
140   MAT   B  =   (-5) * A
```

ALL ELEMENTS OF B(,) SET TO -5

MAT A = IDN

"IDN" IS SHORT FOR *IDENTITY*. (AN "IDENTITY MATRIX" IN MATRIX ALGEBRA IS ANALOGOUS TO *UNITY* IN ORDINARY ALGEBRA: THIS IS DEMONSTRATED ON PAGE 91.) THE IDENTITY MATRIX HAS 1'S ON THE *DIAGONAL* (WHERE ROW & COLUMN SUBSCRIPTS ARE EQUAL) AND 0'S *OFF THE DIAGONAL* (WHERE SUBSCRIPTS ARE *UN*EQUAL). HERE IS ONE WAY TO PROGRAM IT:

	1)	2)	3)
A(1,	1	0	0
A(2,	0	1	0
A(3,	0	0	1

```
200   FOR R = 1 TO 3
210   FOR C = 1 TO 3
220   LET A(R,C)=1-ABS(SGN(R-C))
230   NEXT C
240   NEXT R
```

BUT YOU CAN DO IT WITH A SINGLE "MAT" INSTRUCTION:

```
150   MAT   A  =   IDN (3,3)
```

IDENTITY MATRICES ARE ALWAYS SQUARE

YOU MAY LEAVE OFF THE DIMENSIONS AND HAVE JUST "MAT A=IDN" BUT ONLY IF THE *CURRENT* DIMENSIONS OF A(,) ARE EQUAL.

YOU MAY ALSO HAVE *EXPRESSIONS* FOR DIMENSIONS INSTEAD OF WRITTEN INTEGERS AS ABOVE. FOR EXAMPLE "MAT A=IDN(X,2*Y+3)". BUT THE RESULTS OF BOTH EXPRESSIONS MUST BE THE SAME WHEN *BASIC* EVALUATES THEM BECAUSE THERE IS NO SUCH THING AS A *NON*-SQUARE IDENTITY MATRIX. FURTHERMORE YOU SHOULD MAKE CERTAIN YOUR EXPRESSIONS CAN ONLY YIELD INTEGRAL RESULTS FOR THE REASONS GIVEN OPPOSITE.

INVERSION

FIRST A BRIEF INTRODUCTION TO THE MEANING OF "INVERSE".

FOR AN ORDINARY ALGEBRAIC EQUATION:

$$4.5\ X = 37$$

THE SOLUTION IS:

$$\begin{aligned} X &= (4.5)^{-1} \times 37 \\ &= 0.2222 \times 37 \\ &= 8.222 \end{aligned}$$

THE PROCEDURE IS TO "INVERT" THE COEFFICIENT OF X AND MULTIPLY BY THE RIGHT-HAND SIDE (*RHS*). NOTICE THAT THE ORIGINAL COEFFICIENT, 4.5, MULTIPLIED BY ITS "INVERSE", 0.2222, IS 0.9999.... (IDEALLY EXACTLY 1).

IN *MATRIX* ALGEBRA THERE IS AN ANALOGOUS APPROACH TO *SIMULTANEOUS* EQUATIONS. CONSIDER THESE THREE:

$$\begin{aligned} 15X + 10Y + 5Z &= 3.1 \\ 12X + 24Y + 8Z &= 4.5 \\ 6X \quad\quad + 36Z &= 6.3 \end{aligned}$$

THEY MAY BE WRITTEN IN MATRIX FORM LIKE THIS:

$$\begin{bmatrix} 15 & 10 & 5 \\ 12 & 24 & 8 \\ 6 & 0 & 36 \end{bmatrix} * \begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = \begin{bmatrix} 3.1 \\ 4.5 \\ 6.3 \end{bmatrix}$$

(IF YOU FORM THE INNER PRODUCT OF ROW 1 OF THE FIRST MATRIX AND COLUMN 1 OF THE SECOND YOU GET $15 \times X + 10 \times Y + 5 \times Z$ *etc.* JUST AS THE INNER PRODUCTS ARE SET OUT ON PAGE 88.)

THE SOLUTION OF THE EQUATIONS IS:

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = \begin{bmatrix} 15 & 10 & 5 \\ 12 & 24 & 8 \\ 6 & 0 & 36 \end{bmatrix}^{-1} * \begin{bmatrix} 3.1 \\ 4.5 \\ 6.3 \end{bmatrix}$$

WHERE THE "-1" AS A SUPERSCRIPT TO THE MATRIX DENOTES THE "INVERSE" OF THAT MATRIX, WHICH (AS WILL BE SHOWN) WORKS OUT LIKE THIS:

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = \begin{bmatrix} \cdot 1029 & -\cdot 0429 & -\cdot 00476 \\ -\cdot 0457 & \cdot 0607 & -\cdot 00714 \\ -\cdot 0171 & \cdot 00714 & \cdot 0286 \end{bmatrix} * \begin{bmatrix} 3.1 \\ 4.5 \\ 6.3 \end{bmatrix}$$

FROM WHICH YOU CAN GET ANSWERS FOR *ANY* RIGHT-HAND SIDE BY MATRIX MULTIPLICATION. FOR EXAMPLE, TO GET Y (ROW 2, COLUMN 1):

$$Y = -0.0457 \times 3.1 + 0.0607 \times 4.5 - 0.00714 \times 6.3 = 0.4598$$

TO COMPLETE THE ANALOGY WITH ORDINARY ALGEBRA, MULTIPLY THE ORIGINAL MATRIX OF COEFFICIENTS BY ITS INVERSE :

$$\begin{bmatrix} 15 & 10 & 5 \\ 12 & 24 & 8 \\ 6 & 0 & 36 \end{bmatrix} * \begin{bmatrix} \cdot 1029 & -\cdot 0429 & -\cdot 00476 \\ -\cdot 0457 & \cdot 0607 & -\cdot 00714 \\ -\cdot 0171 & \cdot 00714 & \cdot 0286 \end{bmatrix} = \begin{bmatrix} 1\cdot 001 & -\cdot 0008 & -\cdot 0088 \\ \cdot 0012 & \cdot 9991 & \cdot 00032 \\ \cdot 0018 & -\cdot 00036 & 1\cdot 001 \end{bmatrix}$$

GIVING A MATRIX VERY NEAR TO THE *IDENTITY* MATRIX — A SORT OF "MATRIX UNITY". (IDEALLY THE ANSWER SHOULD BE PRECISELY THIS BUT WE WORKED TO ONLY 4 SIGNIFICANT FIGURES.)

SO YOU CAN GET THE INVERSE SHOWN ABOVE BY SOLVING 3 SIMULTANEOUS EQUATIONS USING THE COLUMNS OF THE IDENTITY MATRIX AS RIGHT-HAND SIDES — EFFECTIVELY "DIVIDING" *MATRIX UNITY* BY THE COEFFICIENTS — OR "INVERTING" THE MATRIX OF COEFFICIENTS.

$$\begin{array}{rcrcrcl} 15\times X & + & 10\times Y & + & 5\times Z = & 1 \text{ THEN } 0 \text{ THEN } 0 \\ 12\times X & + & 24\times Y & + & 8\times Z = & 0 \quad\quad 1 \quad\quad 0 \\ 6\times X & + & 0\times Y & + & 36\times Z = & 0 \quad\quad 0 \quad\quad 1 \end{array}$$

WE DO THIS AS WE DID AT SCHOOL BUT PERHAPS IN A MORE RIGIDLY-ORDERED SEQUENCE. FIRST ELIMINATE COEFFICIENTS OF X IN EQUATIONS 2 AND 3. MULTIPLY EQ.2 BY 15, DIVIDE THROUGH BY 12, AND SUBTRACT THIS SCALED EQUATION FROM EQ.1 THUS GIVING A NEW EQ.2. SIMILARLY FORM A NEW EQ.3 BY MULTIPLYING EQ.3 BY 15, DIVIDING THROUGH BY 6, AND SUBTRACTING FROM EQ.1.

$$\begin{array}{lrcrcrcrrr} & 15\times X & + & 10\times Y & + & 5\times Z = & 1 & 0 & 0 \\ EQ2 = EQ1-(15/12)\times EQ2\ \ldots & 0\times X & - & 20\times Y & - & 5\times Z = & 1 & -1\cdot 25 & 0 \\ EQ3 = EQ1-(15/6)\times EQ3\ \ldots & 0\times X & + & 10\times Y & - & 85\times Z = & 1 & 0 & -2\cdot 5 \end{array}$$

NOW ELIMINATE THE COEFFICIENT OF Y IN NEW EQUATION 3. MULTIPLY EQ.3 BY −20, DIVIDE THROUGH BY 10, AND SUBTRACT FROM EQ.2.

$$\begin{array}{lrcrcrcrrr} & 15\times X & + & 10\times Y & + & 5\times Z = & 1 & 0 & 0 \\ & 0\times X & - & 20\times Y & - & 5\times Z = & 1 & -1\cdot 25 & 0 \\ EQ3 = EQ2-(-20/10)\times EQ3\ \ldots & 0\times X & + & 0\times Y & - & 175\times Z = & 3 & -1\cdot 25 & -5 \end{array}$$

THE ORIGINAL MATRIX OF COEFFICIENTS NOW HAS ALL ELEMENTS BELOW THE DIAGONAL EQUAL TO ZERO. SO NOW "BACK SUBSTITUTE" STARTING AT EQUATION 3 AND WORKING BACK TO EQUATION 1.

THE ONLY UNKNOWN IN EQ.3 IS Z, SO DIVIDE *RH*-SIDES BY −175 :

$$Z = -\cdot 0171 \quad \cdot 00714 \quad \cdot 0286$$

NOW FROM EACH *RHS* OF EQ.2 SUBTRACT (−5) TIMES THE CORRESPONDING VALUE OF Z, AND DIVIDE BY THE COEFFICIENT OF Y WHICH IS (−20) (*e.g.* THE FIRST IS $[1-(-5)\times(-\cdot 0171)]\div(-20) = -\cdot 0457$).

$$Y = -\cdot 0457 \quad \cdot 0607 \quad -\cdot 00714$$

FINALLY, FROM EACH *RHS* OF EQ.1 SUBTRACT 5 TIMES THE CORRESPONDING VALUE OF Z, 10 TIMES THE CORRESPONDING VALUE OF Y, AND DIVIDE BY 15 (*e.g.* THE FIRST IS $[1-5*(-\cdot 0171)-10\times(-\cdot 0457)]\div 15 = \cdot 1029$).

$$X = \cdot 1029 \quad -\cdot 0429 \quad -\cdot 00476$$

THESE ARE THE 3 ROWS OF THE INVERSE — PRODUCED IN REVERSE ORDER.

MAT A = INV(B)

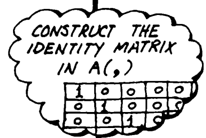
```
10    DIM    A(3,3),  B(3,3),  I(3,3)
```

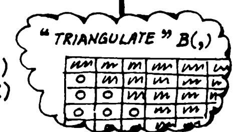
	1)	2)	3)
A(1,			
A(2,			
A(3,			

	1)	2)	3)
B(1,	15	10	5
B(2,	12	24	8
B(3,	6	0	36

HERE IS A ROUTINE TO INVERT A MATRIX OF DIMENSIONS N BY N STORED AS AN ARRAY B(,): THE INVERSE IS BUILT UP IN A(,). THE METHOD USED IS EXPLAINED BY THE EXAMPLE ON THE PREVIOUS DOUBLE PAGE.

```
200   REM    A(,) = INVERSE B(,);  N BY N.
210   FOR    I = 1 TO N
220   FOR    J = 1 TO N
230   LET    A(I,J) = 1 - ABS(SGN(I-J))
240   NEXT   J
250   NEXT   I
260   FOR    I = 1 TO N-1
270   IF     ABS(B(I,I)) > 0.00001 THEN 300
280   PRINT  "CAN'T COPE WITH"; B(I,I)
290   STOP
300   FOR    J = I+1 TO N
310   LET    X = B(J,I) / B(I,I)
320   FOR    K = 1 TO N
330   LET    B(J,K) = B(J,K) - X* B(I,K)
340   LET    A(J,K) = A(J,K) - X* A(I,K)
350   NEXT   K
360   NEXT   J
370   NEXT   I
380   FOR    I = N TO 1 STEP -1
390   FOR    K = 1 TO N
400   FOR    J = I+1 TO N
410   LET    A(I,K) = A(I,K) - B(I,J)*A(J,K)
420   NEXT   J
430   LET    A(I,K) = A(I,K) / B(I,I)
440   NEXT   K
450   NEXT   I
```





"BACK SUBSTITUTE" IN A(,)

BUT YOU MAY DO THIS MUCH BETTER WITH A SINGLE "MAT" INSTRUCTION:

```
100   MAT    A = INV(B)
```

IF THE MATRIX HAS NO INVERSE (IF IT IS "SINGULAR") THEN SOME *BASICS* REPORT AN ERROR AND STOP EXECUTION; OTHERS DON'T REPORT AN ERROR BUT PROVIDE THE MEANS OF PICKING UP THE *DETERMINANT* OF THE MATRIX AS SHOWN BELOW. A ZERO DETERMINANT IMPLIES A SINGULAR MATRIX. (A DETERMINANT IS ILLUSTRATED ON PAGE 43.)

```
110   LET  D = DET
120   IF   D > .001   THEN   150
130   PRINT "SINGULAR MATRIX"
140   STOP
```

CARRY ON

THE VALUE PROVIDED BY "DET" IS THE VALUE OF THE DETERMINANT OF THE MATRIX LAST INVERTED (OR LAST ATTEMPTED) BY YOUR PROGRAM. NOT ALL *BASICS*, HOWEVER, PROVIDE THE "DET" FUNCTION.

A *NON*-SQUARE MATRIX CAN HAVE NO INVERSE; ATTEMPTS TO COMPUTE ONE ARE TREATED AS MISTAKES. AND MOST *BASICS* REFUSE TO REPLACE A MATRIX BY ITS OWN INVERSE.

```
150   MAT   A = CON(2,3)
160   MAT   B = INV(A)
170   MAT   B = INV(B)
```

NOT SQUARE

SAME NAME BOTH SIDES

YOU CAN JUDGE THE ACCURACY OF INVERSION BY PRINTING THE PRODUCT OF THE ORIGINAL MATRIX AND ITS INVERSE. BY DEFINITION THIS SHOULD BE THE IDENTITY MATRIX EXACTLY BUT USUALLY DIFFERS BECAUSE OF "ROUNDING" ERRORS AS PREVIOUSLY ILLUSTRATED USING FOUR SIGNIFICANT FIGURES.

```
180   MAT   A = INV(B)
190   MAT   I = B * A
195   MAT   PRINT I
```

"MAT PRINT" IS DESCRIBED ON PAGE 98

THE DIMENSIONS OF A(,) IN ITS "DIM" STATEMENT MUST BE AT LEAST AS BIG AS THE *CURRENT* DIMENSIONS OF B(,) AT LINE 180 ABOVE. IMPLICATIONS OF RE-DIMENSIONING ARE DISCUSSED ON PAGE 79.

THE ROUTINE FROM LINE 200 OPPOSITE DIFFERS IN ITS EFFECT FROM "MAT A=INV(B)". FIRST OF ALL IT MAKES A MESS OF ARRAY B(,); THE "MAT" INSTRUCTION SHOULD *NOT* DO THIS. (IF YOUR VERSION *DOES* MANGLE B(,) IT WILL BE EVIDENT WHEN YOU RUN THE TEST AT LINE 180 ABOVE.) SECONDLY THE ROUTINE OPPOSITE ONLY WORKS WELL IF NUMBERS ON THE DIAGONAL OF B(,) ARE MUCH THE SAME SIZE AS ONE ANOTHER AND BIGGER THAN TERMS *OFF* THE DIAGONAL. (IT WILL NOT WORK AT ALL IF B(1,1) IS ZERO.) THE "MAT" INSTRUCTION SHOULD SELECT BEST DIVISORS; NOT SIMPLY USE DIAGONAL ELEMENTS AS DONE AT LINE 310 OPPOSITE FOR THE SAKE OF A SIMPLE ILLUSTRATION.

MAT READ

THIS INSTRUCTION READS FROM THE SAME "DATA" STATEMENTS AS THE ORDINARY "READ".

```
10  DIM   A(2,3),  B(3,1),  C(1,3)
20  DATA  1.5, 2.3, 3.2, 4.6, 5.7, 6.5, 7.1
30  DATA  8.9, 9.0, 11.7, 12.6, 13, 14, 15
```

	1)	2)	3)
A(1,	1.5	2.3	3.2
A(2,	4.6	5.7	6.5

	1)
B(1,	7.1
B(2,	8.9
B(3,	9.0

	1)	2)	3)
C(1,	11.7	12.6	13

SUPPOSE YOU WANT TO FILL ARRAY A(,) BY ROWS FROM THE QUEUE OF DATA STARTING ON LINE 20. YOU COULD DO IT LIKE THIS:

```
200  FOR   R = 1 TO 2
210  FOR   C = 1 TO 3
220  READ  A(R,C)
230  NEXT  C
240  NEXT  R
```

BUT YOU COULD DO THE WHOLE THING WITH A SINGLE "MAT" STATEMENT LIKE THIS:

```
100  MAT  READ  A
```

A(,) IS READ BY ROWS

IN FACT YOU MAY FILL ANY NUMBER OF ARRAYS (BY ROWS) USING A SINGLE "MAT" INSTRUCTION:

```
100  MAT  READ  A, B, C
```

ALWAYS COMMAS IN THIS LIST

THE ARRAYS A(,), B(,) & C(,) WOULD THEN BE AS SHOWN AT THE TOP OF THIS PAGE. NOTICE THE LETTERS A, B & C HAVE NOTHING TO DO WITH SIMPLE VARIABLES A, B & C.

ON THE OTHER HAND YOU MAY *PARTIALLY* FILL ARRAYS BY SPECIFYING NEW DIMENSIONS IN THE "MAT" INSTRUCTION — AS LONG AS THEY ARE NO BIGGER THAN THOSE IN THE "DIM" STATEMENTS.

```
100  MAT  READ  A(2,2), B,  C(1,1)
```

	1)	2)
A(1,	1.5	2.3
A(2,	3.2	4.6

	1)
B(1,	5.7
B(2,	6.5
B(3,	7.1

	1)
C(1,	8.9

IF YOU OMIT DIMENSIONS FROM "MAT READ" THEN *BASIC* USES THE *CURRENT* DIMENSIONS OF THAT ARRAY — THESE MAY BE SMALLER THAN THOSE IN ITS "DIM" STATEMENT.

```
100   MAT   A = ZER(1,1)
110   MAT   READ   A
```

THUS THE INSTRUCTIONS ABOVE WOULD CAUSE JUST ONE NUMBER TO BE READ INTO THE 1 BY 1 ARRAY A(,). IMPLICATIONS OF SUCH RE-DIMENSIONING ARE DISCUSSED ON PAGE 79.

YOU MAY HAVE VARIABLES OR EXPRESSIONS AS DIMENSIONS IN THE "MAT" STATEMENT:

```
10   DIM    E(10,10)                  DIMENSIONS
20   DATA   2, 3                      AS DATA
30   DATA   1.1, 2.2, 3.3, 4.4, 5.5, 6.6
40   READ   R, C                      EXPRESSIONS
50   MAT    READ   E(R,C)             ALLOWED HERE
```

BUT ALWAYS ENSURE (PERHAPS BY USING "INT") THAT THE EXPRESSIONS YIELD INTEGRAL RESULTS BECAUSE SOME *BASICS* USE THE *NEAREST* INTEGER TO THE RESULT AND OTHERS USE THE *INTEGRAL PART*.

THERE IS ONLY ONE QUEUE OF DATA IN THE "DATA" STATEMENTS AND EACH "READ" OR "MAT READ" TAKES WHAT IT NEEDS WHEN OBEYED. THE INSTRUCTION "RESTORE" TAKES THE PROGRAM BACK TO THE BEGINNING OF THE QUEUE AS EXPLAINED ON PAGE 17.

THE "MAT READ" INSTRUCTION IS USEFUL FOR SETTING UP "STATE TABLES" IN PROGRAMS THAT USE SUCH DEVICES: A FULL EXAMPLE IS INCLUDED ON PAGE 102.

MAT INPUT

THIS INSTRUCTION DEMANDS COMPLETE ARRAYS AS INPUT DATA.

```
10   DIM   A(3,3)
```

	1)	2)	
A(1,	1·5	2·6	
A(2,	3·7	4·8	

HERE IS ONE WAY TO FILL A SPECIFIC PART OF AN ARRAY WITH NUMBERS DEMANDED FROM THE KEYBOARD.

```
200   PRINT "TYPE THE DIMENSIONS"
210   INPUT R,C
220   FOR I = 1 TO R
230   PRINT "TYPE ROW"; I;"ONE NUMBER PER LINE"
240   FOR J = 1 TO C
250   INPUT A(I,J)
260   NEXT J
270   NEXT I
280   END
RUN
TYPE THE DIMENSIONS
? 2,2
TYPE ROW 1 ONE NUMBER PER LINE
? 1.5
? 2.6
TYPE ROW 2 ONE NUMBER PER LINE
? 3.7
? 4.8
```

THIS COULD BE ACHIEVED IN A DIFFERENT WAY USING THE "MAT INPUT" INSTRUCTION LIKE THIS:

```
100   PRINT "TYPE THE DIMENSIONS"
110   INPUT R,C
120   PRINT "TYPE"; R;"ROWS OF"; C;"NUMBERS"
130   MAT INPUT A(R,C)
140   END
RUN
TYPE THE DIMENSIONS
? 2,2
TYPE 2 ROWS OF 2 NUMBERS
? 1.5, 2.6
? 3.7, 4.8
```

WHENEVER YOU WANT TO DEMAND DATA FROM THE KEYBOARD IT IS BETTER TO WRITE A SPECIAL INPUT ROUTINE (SUCH AS THAT STARTING AT LINE 200) THAN TO USE THE "MAT INPUT" INSTRUCTION. THREE REASONS ARE:

YOU CAN PRINT HELPFUL INTERMEDIATE MESSAGES SUCH AS THAT ON LINE 230 – IMPOSSIBLE USING "MAT INPUT".

YOU MAY TEST THE RANGE OF EACH NUMBER AS TYPED AND TAKE ACTION BEFORE THE WHOLE ARRAY HAS BEEN TYPED. FOR EXAMPLE, IF YOU KNOW THAT ALL NUMBERS SHOULD BE *SMALLER* THAN ±10:

```
252   IF ABS(A(I,J)) < 10 THEN 260
254   PRINT "OUT OF RANGE; RETYPE COL."; J
256   GO TO 250
```

THEN YOU COULD INSERT THIS ROUTINE IN THE ROUTINE OPPOSITE.

TYPING ONLY ONE NUMBER PER LINE AVOIDS AN EMBARRASSING PROBLEM: WHAT IF YOU CAN'T GET THE WHOLE ROW ON ONE LINE? SOME *BASICS* ALLOW AN AMPERSAND – & – AT THE END OF THE LINE TO SAY "I HAVEN'T FINISHED THE ROW YET": OTHER *BASICS* OFFER DIFFERENT SOLUTIONS.

SO FOR THE SAKE OF PORTABILITY, IF NOTHING ELSE, *DON'T* USE "MAT INPUT" FOR DEMANDING DATA FROM THE KEYBOARD. THIS INSTRUCTION IS USEFUL FOR OTHER PURPOSES AS WILL BE SHOWN.

THE LIST FOLLOWING "MAT INPUT" MAY CONTAIN NAMES OF ANY NUMBER OF ARRAYS; ANY OF THESE NAMES MAY HAVE DIMENSIONS AFTER THEM. AS IN THE CASE OF "MAT READ" THE DIMENSIONS MAY BE INTEGERS, VARIABLES OR EXPRESSIONS AS LONG AS THE VALUES EXPRESSED DO NOT EXCEED THOSE IN THE "DIM" STATEMENTS. IF YOU USE EXPRESSIONS FOR DIMENSIONS MAKE SURE THEY WILL ALWAYS YIELD INTEGRAL RESULTS BECAUSE SOME *BASICS* USE THE *NEAREST* INTEGER TO THE RESULT AND OTHERS THE *INTEGRAL PART*. SOME OTHER IMPLICATIONS OF RE-DIMENSIONING ARE DISCUSSED ON PAGE 79.

```
150   MAT INPUT A, B(2,1), C(2*X, Y)
```

ALWAYS COMMAS

MAT PRINT

THIS INSTRUCTION CAUSES COMPLETE ARRAYS TO BE PRINTED.

```
10   DIM   A(3,3),   B(2,3),   C(2,3)
20   MAT   A = IDN(2,2)
30   MAT   B = CON
40   MAT   C = (-1.5)*B
```

	1)	2)
A(1,	1	0
A(2,	0	1

	1)	2)	3)
B(1,	1	1	1
B(2,	1	1	1

	1)	2)	3)
C(1,	-1.5	-1.5	-1.5
C(2,	-1.5	-1.5	-1.5

HERE IS A ROUTINE TO PRINT THE 2 BY 2 MATRIX STORED IN ARRAY A(,) AND TO PRINT IT BY ROWS.

```
200  PRINT              START A NEW LINE
210  FOR  R=1 TO 2
220  FOR  C=1 TO 2      ; ENSURES RESULTS ARE CLOSE TOGETHER IN EACH ROW
230  PRINT  A(R,C);
240  NEXT  C
250  PRINT              START A NEW LINE
260  PRINT              ONE BLANK LINE BETWEEN ROWS
270  NEXT  R
```

YOU CAN DO THIS WITH A SINGLE "MAT" INSTRUCTION:

```
100  MAT  PRINT  A;     PRINT RESULTS CLOSE TOGETHER
```

AND YOU MAY PRINT ANY NUMBER OF ARRAYS WITH A SINGLE "MAT" INSTRUCTION. THE PUNCTUATION IS EXPLAINED IN MORE DETAIL OPPOSITE.

```
110  MAT  PRINT  A; C,     PRINT C(,) IN ZONES
```

THESE ARRAYS GET PRINTED BY ROWS. (IF YOU WANT *COLUMNS* OF AN ARRAY PRINTED AS ROWS ON THE PAGE USE "MAT B=TRN(A)" FIRST.) THESE ARRAYS ARE PRINTED ACCORDING TO THEIR *CURRENT* DIMENSIONS. THUS ARRAY A(,) WHEN PRINTED WOULD HAVE 2 ROWS WITH 2 NUMBERS IN EACH ROW: IT WAS GIVEN THESE DIMENSIONS ON LINE 20 ABOVE. ARRAY C(,) WOULD HAVE 2 ROWS, EACH OF 3 NUMBERS.

DON'T WRITE DIMENSIONS IN THIS INSTRUCTION. *BASIC KNOWS* THE CURRENT DIMENSIONS OF ALL ARRAYS AND OBJECTS TO BEING REMINDED.

```
120  MAT  PRINT  A(2,2) ; C     COMMA IMPLIED BY OMISSION
```

LAYOUT OF THE OUTPUT PAGE FOLLOWS THE RULES GIVEN BELOW THOUGH THERE MAY BE MINOR DIFFERENCES IN SOME *BASICS*.

EVERY ROW OF THE ARRAY STARTS A NEW LINE ON THE OUTPUT PAGE.

THERE IS A BLANK LINE ON THE OUTPUT PAGE AFTER EVERY PRINTED ROW OF THE ARRAY.

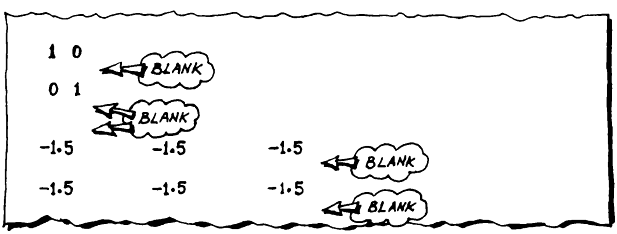
IF A ROW OF THE ARRAY DEMANDS MORE THAN THE WIDTH OF THE OUTPUT PAGE (TYPICALLY 72 CHARACTERS) THEN THE ROW IS CONTINUED ON THE NEXT LINE OF THE OUTPUT PAGE.

IF A SEMICOLON FOLLOWS THE NAME OF AN ARRAY IN THE LIST AFTER "MAT PRINT" THEN THE NUMBERS IN EACH ROW ARE PRINTED CLOSE TOGETHER; IF A COMMA FOLLOWS THE NAME THEN THE NUMBERS ARE PRINTED IN ZONES (TYPICALLY 15 CHARACTERS WIDE). THE PRECISE EFFECTS OF SEMICOLONS AND COMMAS IN THIS CONTEXT ARE EXPLAINED ON PAGE 29.

IF THERE IS NO PUNCTUATION AFTER THE FINAL NAME LISTED IN THE "MAT PRINT" INSTRUCTION THEN A COMMA IS IMPLIED BY OMISSION. (PUNCTUATION IS ESSENTIAL *BETWEEN* ITEMS IN THIS LIST.)

YOU MAY FIND THE RIGID FORMAT IMPOSED BY THIS INSTRUCTION GIVES LITTLE SCOPE FOR DESIGNING ATTRACTIVE PAGE LAYOUTS BUT THE INSTRUCTION IS VERY USEFUL WHEN DEVELOPING NEW PROGRAMS.

WITH THE ARRAYS AT THE TOP OF THE OPPOSITE PAGE THE OUTPUT GENERATED BY LINE 110 WOULD LOOK LIKE THIS:



6

COMPLETE EXAMPLE PROGRAMS

MCDXCII

A PROGRAM TO CONVERT **ROMAN** TO MORE FAMILIAR NUMBERS.

THIS EXAMPLE DEMONSTRATES THE USE OF A *SYMBOL-STATE* TABLE — A STANDARD TOOL IN PROGRAMMING —

ASSUME ALL VALID ROMAN NUMBERS ARE COMPOSED OF THE FOLLOWING ELEMENTS — NEVER MORE THAN ONE FROM EACH CONSECUTIVE BOX:

THOUSANDS	HUNDREDS		TENS		UNITS	
		D = 500		L = 50		V = 5
M = 1000	C = 100	DC = 600	X = 10	LX = 60	I = 1	VI = 6
MM = 2000	CC = 200	DCC = 700	XX = 20	LXX = 70	II = 2	VII = 7
MMM = 3000	CCC = 300	DCCC = 800	XXX = 30	LXXX = 80	III = 3	VIII = 8
ARBITRARY UPPER LIMIT	CD = 400	CM = 900	XL = 40	XC = 90	IV = 4	IX = 9

(IT SEEMS CLASSICAL ROME SELDOM USED THE *SUBTRACTIVE* PRINCIPLE INHERENT IN IV, PREFERRING IIII, BUT THIS PROGRAM REFUSES TO HANDLE MORE THAN THREE CONSECUTIVE LETTERS OF THE SAME KIND.)

THE LOGIC OF THE PROGRAM IS CONTAINED IN THE FOLLOWING SYMBOL-STATE TABLE:

"STATE"	"SYMBOL" M	D	C	L	X	V	I
STARTING STATE → 01	1000 & 02	500 & 03	100 & 09	50 & 05	10 & 10	5 & 07	1 & 11
02	1000 & 02	500 & 03	100 & 09	50 & 05	10 & 10	5 & 07	1 & 11
03	ERROR	ERROR	100 & 09	50 & 05	10 & 10	5 & 07	1 & 11
04	ERROR	ERROR	100 & 04	50 & 05	10 & 10	5 & 07	1 & 11
05	ERROR	ERROR	ERROR	50 & 06	10 & 10	5 & 07	1 & 11
06	ERROR	ERROR	ERROR	ERROR	10 & 06	5 & 07	1 & 11
07	ERROR	ERROR	ERROR	ERROR	ERROR	5 & 08	1 & 11
08	ERROR	ERROR	ERROR	ERROR	ERROR	ERROR	1 & 08
09	800 & 05	300 & 05	100 & 04	50 & 06	10 & 10	5 & 08	1 & 11
10	ERROR	ERROR	80 & 07	30 & 07	10 & 06	5 & 08	1 & 11
11	ERROR	ERROR	ERROR	ERROR	8 & 00	3 & 00	1 & 08

TAKE THE ROMAN NUMBER **CIX** AS AN EXAMPLE: BEGIN WITH A VALUE OF ZERO. YOU ARE IN *STATE* 01 (WHERE THE ARROW IS) SO LOOK DOWN FROM *SYMBOL* **C** AND FIND 100&09 WHICH SAYS "ADD 100 TO THE VALUE & CHANGE *STATE* TO 09". SO ADD 100 TO ZERO & MOVE THE ARROW TO 09. NOW LOOK DOWN FROM *SYMBOL* **I** AND FIND 1&11; SO ADD 1 TO THE VALUE (100+1=101) & MOVE THE ARROW TO *STATE* 11. FINALLY LOOK DOWN FROM *SYMBOL* **X** AND FIND 8&00; SO ADD 8 TO THE VALUE (101+8=109). THE 00 MEANS YOU'VE FINISHED.

THE TABLE IS PART OF THE COMPUTER PROGRAM AND PREPARED AS SHOWN BELOW. TO SAVE SPACE EACH ELEMENT OF A(,) IS MADE TO CONTAIN BOTH THE NUMBER TO BE ADDED *AND* THE NUMBER OF THE NEW STATE THUS 5 & 07 BECOMES 100*5 + 07 = 507. THE ENTRIES SAYING "ERROR" ARE ENTERED AS −1.

```
10   REM    DECODE  ROMAN  NUMERALS
20   DIM    A(11,7),   C$(7)
30   REM  EACH ELEMENT = 100*ADDITION + NEWSTATE
100  REM          M,       D,       C,     L,    X,   V,   I
110  DATA  100002,  50003,  10009,  5005, 1010, 507, 111
120  DATA  100002,  50003,  10009,  5005, 1010, 507, 111
130  DATA      -1,     -1,  10009,  5005, 1010, 507, 111
140  DATA      -1,     -1,  10004,  5005, 1010, 507, 111
150  DATA      -1,     -1,     -1,  5006, 1010, 507, 111
160  DATA      -1,     -1,     -1,    -1, 1006, 507, 111
170  DATA      -1,     -1,     -1,    -1,   -1, 508, 111
180  DATA      -1,     -1,     -1,    -1,   -1,  -1, 108
190  DATA   80005,  30005,  10004,  5006, 1010, 508, 111
200  DATA      -1,     -1,   8007,  3007, 1006, 508, 111
210  DATA      -1,     -1,     -1,    -1,  800, 300, 108
220  REM
230  MAT READ  A(11,7)
240  DATA  "M",  "D",  "C",  "L",  "X",  "V",  "I"
250  READ  C$(1), C$(2), C$(3), C$(4), C$(5), C$(6), C$(7)
260  REM
```

THE TEXTUAL ARRAY C$( ) IS NOW LIKE THIS:

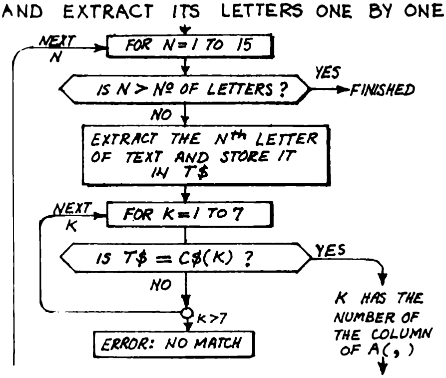
C$(1)	C$(2)	C$(3)	C$(4)	C$(5)	C$(6)	C$(7)
M	D	C	L	X	V	I

IDEALLY WE SHOULD NOW "INPUT" A SINGLE TEXT LIKE "MCDXCII" AND EXTRACT ITS LETTERS ONE BY ONE FOR MATCHING IN ARRAY C$( ). UNFORTUNATELY *BASICS* CAN'T AGREE HOW TO DO IT. SUPPOSE YOU HAD THIS TEXT:

LET P$ = "FRUSTRATION"

& WANTED TO PUT "RAT" INTO A$; HERE ARE JUST *SOME* WAYS TO DO IT.

```
LET  A$ = SUBSTR(P$,6,3)
LET  A$ = P$(6,8)
LET  A$ = STR(P$,6,3)
LET  A$ = MID(P$,6%,3%)
LET  A$ = EXT$(P$,6,8)
LET  A$ = P$(:6,3)
LET  A£ = SUB£(P£,6,3)
```



SO WE SHALL BE CONTENT TO "INPUT" LETTERS ONE BY ONE; SEE OVERLEAF.

HERE IS THE MAIN BODY OF THE PROGRAM FOR DECODING ROMAN NUMERALS:

```
300 REM   MAIN PROGRAM STARTS
310 PRINT "TYPE ROMAN NUMBERS LETTER BY LETTER"
320 PRINT "END NUMBERS WITH *  END RUN WITH **"
330 PRINT "NUMBERS ENDING IV & IX NEED NO *"
340 PRINT
350 PRINT "START"
360 LET R = 1                      INITIAL "STATE" IN THE TABLE
370 LET M = 0                      ACCUMULATE RESULT IN M
380 LET C = 0                      COUNT OCCURRENCES OF IDENTICAL CONSECUTIVE LETTERS
390 LET P = 0                      "PREVIOUS" LETTER
400 INPUT T$
410 IF T$ = "**" THEN 610          END OF RUN
420 IF T$ = "*" THEN 580           PRINT ACCUMULATED VALUE IN M
430 FOR K = 1 TO 7
440 IF T$ = C$(K) THEN 480
450 NEXT K
460 PRINT "CRAZY ROMAN NUMBER"
470 GO TO 340                      NEW START
480 LET X = A(R,K)                 PICK UP ELEMENT FROM TABLE
490 IF X<0 THEN 460                -1 IN TABLE MEANS ERROR
500 REM  ENSURE ONLY 3 OCCURRENCES OF ANY 1 LETTER
510 LET C = (1-ABS(SGN(K-P)))*(1+C)    IF "PREVIOUS"="CURRENT" THEN C=C+1 ELSE C=0
520 IF C>2 THEN 460
530 LET P=K                        SET "PREVIOUS" TO "CURRENT"
540 REM ACCUMULATE RESULT IN M; CHANGE STATE R
550 LET M=M+INT(X/100)             1st PART OF ELEMENT
560 LET R=X-100*INT(X/100)         2nd PART = NEW STATE
570 IF R <> 0 THEN 400             INPUT NEXT LETTER
580 REM PRINT THE RESULT
590 PRINT M
600 GO TO 340                      NEW START
610 END

RUN

TYPE ROMAN NUMBERS LETTER BY LETTER
END NUMBERS WITH *  END RUN WITH **
NUMBERS ENDING IV & IX NEED NO *
START
? M
? M
? I
? *
 2001
```

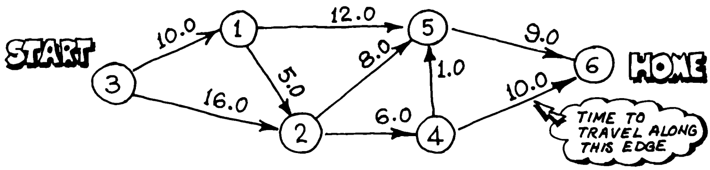
```
START
? M
? C
? M
? L
? X
? X
? X
? I
? V        NO * BECAUSE NUMBER ENDS IN IV
 1984

START
? V
? *
 5

START
? **       END OF RUN
```

IN THIS EXAMPLE THE FIRST PART OF EACH ELEMENT OF THE SYMBOL-STATE TABLE IS SIMPLY A NUMBER TO BE ADDED INTO VARIABLE "M". IN MORE SERIOUS APPLICATIONS THIS WOULD BE THE LINE NUMBER OF A SUBROUTINE. AFTER PICKING UP AN ELEMENT (AS AT LINE 480) THERE WOULD BE AN "ON" INSTRUCTION CAUSING A JUMP TO THE PARTICULAR SUBROUTINE SELECTED BY THAT ELEMENT. AFTER RETURNING FROM THE SUBROUTINE THERE WOULD BE AN INSTRUCTION CAUSING A CHANGE OF STATE JUST AS THAT ON LINE 560.

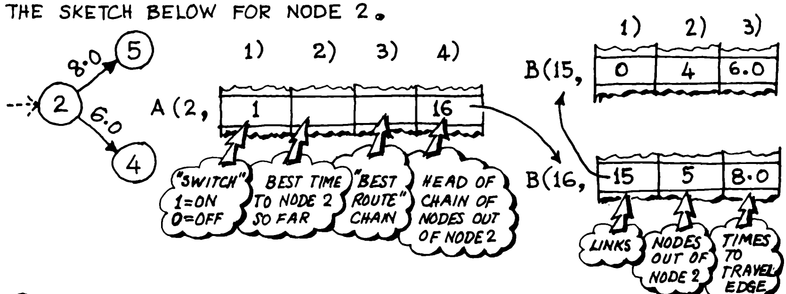
BEST WAY HOME

A PROBLEM COMMON TO INDUSTRY AND COMMERCE.

HERE IS AN EXAMPLE OF AN "ALGORITHM" (COMPUTER JARGON FOR "METHOD") BY WHICH YOU CAN TRACE THE QUICKEST ROUTE THROUGH A NETWORK OF "NODES" AND "EDGES". (ANOTHER APPLICATION OF THE TECHNIQUE SHOWN IS "CRITICAL-PATH ANALYSIS".) THIS ALGORITHM WORKS AS LONG AS THERE IS NO MORE THAN ONE EDGE IN ONE DIRECTION BETWEEN ANY TWO NODES.



THIS IS HOW IT WORKS. YOU KEEP TRACK OF THINGS AS SHOWN IN THE SKETCH BELOW FOR NODE 2.



STARTING AT NODE 3 VISIT EACH NODE IN TURN — 3, 4, 5, 6, CONTINUING ROUND AGAIN — 1, 2, 3, 4, 5, 6, 1, 2, *etc.* UNTIL ALL THE "SWITCHES" ARE "OFF". AT EACH NODE DO THE FOLLOWING — AS DESCRIBED FOR NODE 2:

☆ LOOK AT THE SWITCH IN A(2,1). IF THIS IS "OFF" THEN GO ON TO THE NEXT NODE. IF IT IS "ON" THEN:

☆ PICK UP THE BEST TIME SO FAR: THIS IS IN A(2,2).

☆ USE THE HEAD OF CHAIN IN A(2,4) TO START LOOKING AT ALL NODES RUNNING OUT OF NODE 2. FOR EACH LINK IN THE CHAIN DO THE THINGS DESCRIBED BELOW WITH SPECIFIC REFERENCE TO NODE 5:

- PICK UP THE NODE NUMBER (INITIALLY THIS IS 5).
- PICK UP THE TIME TO TRAVEL ALONG THE EDGE TO THAT NODE (INITIALLY 8.0) AND ADD THIS TO THE TIME ALREADY PICKED UP FROM A(2,2) TO GIVE T; (THE TIME TO REACH NODE 5 VIA NODE 2).
- CONSULT A(5,2) TO SEE IF YOU HAVE JUST FOUND A BETTER ROUTE. IF SO:
  - SWITCH "ON" AT A(5,1).
  - REPLACE OLD BEST TIME A(5,2) WITH T.
  - PUT NODE NUMBER 2 INTO A(5,3) THUS BUILDING A CHAIN THROUGH NODES ON THE BEST ROUTE.

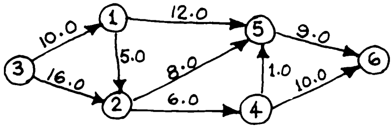
HAVING COMPLETED WORK AT EACH NODE, *SWITCH OFF* THAT NODE.

ARRAYS A(,) & B(,) MUST BE PREPARED BEFORE WORKING ROUND THE NODES AS DESCRIBED ABOVE. ALL THE SWITCHES MUST BE SWITCHED ON, SOME IMPOSSIBLY HIGH JOURNEY TIMES PUT INTO THE SECOND COLUMN OF A(,), AND EVERY NODE MUST BE LINKED TO THE NODES RUNNING OUT OF IT. THE JOURNEY TIME TO THE STARTING NODE MUST BE SET TO ZERO.

```
10  REM QUICKEST WAY HOME: DEMONSTRATE ALGORITHM ONLY
20  REM (DATA NOT CHECKED FOR ABSURDITIES)
30  REM ALLOW FOR 50 NODES AND 120 EDGES
40  DIM A(50,4), B(120,3)
50  PRINT "NO. OF NODES, NO.OF EDGES, START NODE, HOME NODE"
60  INPUT             N,           E,          S,         H
70  FOR I = 1 TO N
80  LET A(I,1) = 1                  SWITCH ON
90  LET A(I,2) = 1000000            VERY HIGH TIME
100  LET A(I,3) = 0                 CLEAR HEADS
110  LET A(I,4) = 0                 & ROUTE CHAIN
120  NEXT I
130  LET A(S,2) = 0                 CLEAR TIME AT STARTING NODE
```

FOR THE PROBLEM ILLUSTRATED OPPOSITE THE FIRST LINE OF INPUT DATA WOULD BE: ? 6, 9, 3, 6 AND ARRAY A(,) WOULD BECOME:

	1)	2)	3)	4)
A(1,	1	1000000	0	0
A(2,	1	1000000	0	0
A(3,	1	0	0	0
A(4,	1	1000000	0	0
A(5,	1	1000000	0	0
A(6,	1	1000000	0	0



NOW INPUT THE DATA DESCRIBING THE EDGES (IN ANY ORDER) AND LINK EACH FOLLOWING NODE TO THE CHAIN OF ITS PREDECESSOR.

INPUT DATA COULD BE PREPARED AS SHOWN HERE.

NO. OF NODES	NO. OF EDGES	START NODE	HOME NODE
6	9	3	6

EDGES A	→ B	TIME FOR EDGE
3	1	10.0
3	2	16.0
1	2	5.0
1	5	12.0
2	4	6.0
2	5	8.0
5	6	9.0
4	6	10.0
4	5	1.0

```
140  REM  INPUT AND LINK (NO CHECKS ON INPUT DATA)
150  PRINT "A--->---B,  EDGE-TIME"
160  FOR  P= 1 TO  E
170  INPUT  A,          B,       R
180  LET  B(P,2) = B
190  LET  B(P,3) = R
200  LET  B(P,1) = A(A,4)
210  LET  A(A,4) = P
220  NEXT  P
```

THE TWO ARRAYS WOULD NOW LOOK LIKE THIS:

	1)	2)	3)	4)
A(1,	1	1000000	0	~~0~~ ~~3~~ 4
A(2,	1	1000000	0	~~0~~ ~~5~~ 6
A(3,	1	0	0	~~0~~ ~~1~~ 2
A(4,	1	1000000	0	~~0~~ ~~8~~ 9
A(5,	1	1000000	0	~~0~~ 7
A(6,	1	1000000	0	0

	1)	2)	3)
B(1,	0	1	10.0
B(2,	1	2	16.0
B(3,	0	2	5.0
B(4,	3	5	12.0
B(5,	0	4	6.0
B(6,	5	5	8.0
B(7,	0	6	9.0
B(8,	0	6	10.0
B(9,	8	5	1.0

THE CROSSING OUT IN THE 4^{TH} COLUMN OF A(,) SHOWS HOW THE CHAINS WERE SUCCESSIVELY LINKED.

HERE IS THE MAIN PART OF THE PROGRAM. VARIABLE K COUNTS THE NUMBER OF TIMES NODE 1 IS PASSED WHILST CYCLING THROUGH THE NODES, BUT K IS SET BACK TO ZERO IF A CHANGE IS MADE TO THE ROUTE. THUS WHEN K GETS TO 2 ALL SWITCHES ARE OFF AND THE SOLUTION CAN BE PRINTED.

```
230  LET I = S                START AT NODE S
240  GO TO 320
250  LET I = I + 1            NEXT NODE
260  IF I <= N THEN 300
270  LET I = 1                BACK TO NODE 1
280  LET K = K + 1            COUNT THE CYCLES
290  IF K > 1 THEN 440
300  REM
310  IF A(I,1) = 0 THEN 250   IF SWITCH IS OFF
320  LET J = A(I,4)
325  IF J = 0 THEN 420
330  LET K = 0                RESET CYCLE COUNT
340  LET T = A(I,2) + B(J,3)  T = TIME TO NODE L
350  LET L = B(J,2)                 VIA NODE I
360  IF A(L,2) < T THEN 400
370  LET A(L,1) = 1           SWITCH ON NODE L
380  LET A(L,2) = T           REPLACE TIME TO L
390  LET A(L,3) = I           ADD LINK TO ROUTE CHAIN
400  LET J = B(J,1)
410  IF J <> 0 THEN 340
420  LET A(I,1) =0            SWITCH OFF NODE I
430  GO TO 250
440  REM   PRINT RESULT
450  PRINT "QUICKEST WAY FROM";S;"TO";H;"TAKES";A(H,2);"THRU"
460  PRINT H;
470  LET X = A(H,3)           HOME LINK OF ROUTE CHAIN
480  IF X=0 THEN 520
490  PRINT X;
500  LET X = A(X,3)
510  GO TO 480
520  PRINT
530  END
```

RUNNING THIS PROGRAM WITH THE DATA SHOWN OPPOSITE PRODUCES THE RESULT:

```
                                        UNITS
                                        OF TIME
QUICKEST WAY FROM 3 TO 6 TAKES 31  THRU
6  5  4  2  1  3
```

AT THE END OF A RUN THE SECOND COLUMN OF A(,) STORES THE QUICKEST TIMES FROM NODE S TO ALL OTHER NODES IN THE NETWORK.

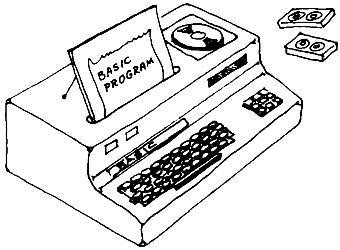
7

COMMANDS AND SIGNING ON

SIGNING ON

CONSULT YOUR USER'S MANUAL; EVERY SYSTEM HAS ITS OWN RULES.

BASIC RUNS ON MINI-COMPUTERS AND MONSTERS ALIKE.

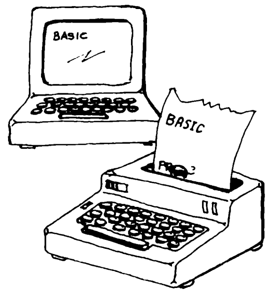


YOU MAY USE A MODERN "DESK-TOP" COMPUTER DESIGNED EXCLUSIVELY FOR DEVELOPING AND RUNNING *BASIC* PROGRAMS.

(SOME OF THESE HAVE KEYS MARKED WITH THE WORDS OF THE LANGUAGE TO SIMPLIFY TYPING.)

OR YOU MAY USE ONE OF SEVERAL "TERMINALS" CONNECTED TO A COMPUTER IN THE BUILDING; OR CONNECTED BY TELEPHONE TO A COMPUTER MILES AWAY.

SOME TERMINALS HAVE A KEYBOARD AND VISUAL-DISPLAY SCREEN LIKE A TELEVISION: OTHERS A KEYBOARD AND PRINTING HEAD FOR TYPING ON PAPER.



BIG COMPUTERS OFFER A CHOICE OF LANGUAGE; *BASIC* IS JUST ONE OF THEM. SOMEHOW YOU HAVE TO TELL THE COMPUTER YOU WANT TO USE *BASIC* AS YOU "SIGN ON".

WHEN YOU SWITCH ON A TERMINAL (AND, IF IT IS CONNECTED TO A TELEPHONE LINE, DIAL THE NUMBER OF A COMPUTER BUREAU) THE FIRST INTELLIGIBLE RESPONSE YOU GET COMES FROM THE COMPUTER'S "OPERATING SYSTEM". YOU THEN HAVE TO TYPE COMMANDS IN A CODE THE OPERATING SYSTEM CAN UNDERSTAND. UNFORTUNATELY THESE CODES ARE TOTALLY DIFFERENT FROM ONE OPERATING SYSTEM TO ANOTHER. SOME HELP YOU BY ASKING QUESTIONS AND SUPPLYING PROMPTS. THE EXAMPLE OPPOSITE CONCERNS AN IMAGINARY SYSTEM SUCH AS THIS BUT YOU WOULD BE LUCKY TO FIND A REAL ONE AS INTELLIGIBLE.

CONVERSATION WITH AN IMAGINARY OPERATING SYSTEM:

```
YOU ARE CONNECTED TO THE "THANATOS" SYSTEM OF
NECROPOLITAN LIFE ASSURANCE INCORPORATED, MORSVILLE.
PLEASE TYPE YOUR ACCOUNT NUMBER
?  123021/6
PASSWORD
?  DAVYJONES
```

MOST SYSTEMS PRINT AND OVERPRINT A BLACK MESS OF CHARACTERS WHEN ASKING FOR YOUR PASSWORD SO THAT WHAT YOU TYPE ON TOP OF THE MESS CAN'T BE DECIPHERED BY CURIOUS BYSTANDERS:

```
PASSWORD
?

USER 123021 SUBACCOUNT 6 SIGNED ON AT 17.03 HRS
WHAT PROCESSOR OR LANGUAGE
?  BASIC
```

THE CONVERSATION WITH THE OPERATING SYSTEM IS NOT QUITE FINISHED ~ BUT THIS IS THE POINT AT WHICH SIMPLER OPERATING SYSTEMS (THOSE FOR COMPUTERS DEDICATED TO *BASIC*) BEGIN WHEN YOU SWITCH ON.

```
NEW PROGRAM OR OLD
?  NEW
GIVE NEW PROGRAM A NAME
?  EXAMPL
```

THE NAME YOU INVENT IS RESTRICTED BY MOST OPERATING SYSTEMS TO ABOUT SIX LETTERS AND DIGITS OF WHICH THE FIRST MUST ALWAYS BE A LETTER.

```
BASIC IS READY
```

THIS IS THE POINT AT WHICH MOST EXAMPLES IN THIS BOOK BEGIN ~ READY TO RECEIVE A NEW PROGRAM TYPED LINE BY LINE PRIOR TO TYPING "RUN".

HAVING SIGNED ON, TYPED A PROGRAM AND RUN IT YOU WILL THEN WANT TO "SIGN OFF". IN MANY SYSTEMS YOU DO THIS BY TYPING "BYE" OR "GOODBYE".

```
BYE

USER 123021 SUBACCOUNT 6 SIGNED OFF AT 17.15 HRS.
TIME CONNECTED = 12 MINS, PROCESSOR TIME = 1.385 SEC.
```

IF YOU GET CONFUSED WHEN CONVERSING WITH AN OPERATING SYSTEM, TRY TYPING "HELP". SOME SYSTEMS DO RESPOND HELPFULLY: OTHERS JUST SAY "WHAT?" ~ BUT IT'S WORTH A TRY.

COMMANDS

EACH COMMAND MAKES *BASIC* DO SOMETHING THE MOMENT IT IS TYPED.

THE MOST IMPORTANT COMMAND OF *BASIC* IS "RUN" BUT THERE ARE OTHERS COMMON TO MANY VERSIONS OF *BASIC* AND BRIEFLY DESCRIBED HERE. MOST *BASICS* HAVE USEFUL COMMANDS FOR PROVIDING LINE NUMBERS AUTOMATICALLY, FOR RE-NUMBERING THE LINES OF A PROGRAM, AND FOR JOINING PROGRAMS TOGETHER, BUT THESE COMMANDS VARY TOO MUCH IN DETAIL TO BE INCLUDED IN THIS BOOK. *ALWAYS CONSULT YOUR MANUAL ABOUT THE COMMANDS OF BASIC.*

```
BASIC IS READY

10  REM  JUST  AN EXAMPLE
20  FOR  A =  1 TO 8
30  PRINT  A;
40  EMD
40  END
32  NEXT  A
10
RUN
 1  2  3  4  5  6  7  8
```

NO LINE NUMBER ~ "RUN" IS NOT PART OF THE PROGRAM. IT CAUSES IMMEDIATE ACTION

IF YOU TYPE "RUN" A SECOND TIME YOU WILL GET THE SAME RESULT AGAIN: *BASIC* DOESN'T FORGET A PROGRAM HAVING OBEYED IT.

```
RUN
 1  2  3  4  5  6  7  8
```

IF YOU TYPE "LIST" *BASIC* WILL PRINT A COPY OF THE PROGRAM YOU HAVE TYPED. IT WILL BE A *CLEAN* COPY HAVING BAD LINES REPLACED OR REMOVED AND OUT-OF-SEQUENCE LINES CORRECTLY INSERTED. COMPARE THE ORIGINAL PROGRAM ABOVE WITH THAT BELOW. (SEE ALSO PAGE 7.)

```
LIST
20  FOR  A = 1  TO  8
30  PRINT  A;
32  NEXT  A
40  END
```

IN SOME *BASICS* TYPING "LIST 30" WOULD CAUSE JUST LINE 30 TO BE PRINTED: IN OTHERS THIS WOULD CAUSE LINE 30 AND ALL SUBSEQUENT LINES TO BE PRINTED. IN SOME *BASICS* TYPING "LIST 20,32" (IN OTHERS "LIST 20–32") CAUSES JUST THAT PART OF THE PROGRAM INCLUDED WITHIN THE STATED RANGE OF LINE NUMBERS TO BE PRINTED.

IF YOU TYPE "SAVE" THEN *BASIC* WILL SAVE IN A "FILE" A COPY OF THE PROGRAM YOU ARE CURRENTLY WORKING ON. THE COMPUTER HAS A *WORKING AREA* (USUALLY IN ITS FAST CORE STORE) AND A *FILES AREA* (USUALLY IN ITS BACKING STORE OF MAGNETIC TAPES AND DISKS). WHEN YOU TYPE "SAVE" A COPY OF THE PROGRAM CURRENTLY IN THE WORKING AREA GOES TO THE FILES AREA. YOU CAN GET IT BACK AGAIN BY TYPING ITS NAME AS DESCRIBED LATER.


```
LIST
20  FOR A = 1 TO 8
30  PRINT  A
32  NEXT  A
40  END
SAVE
```

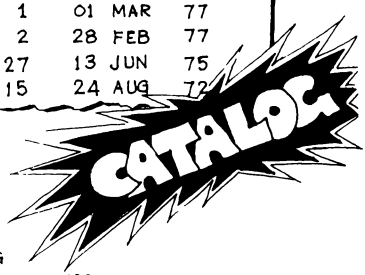
SENDS A COPY OF THIS PROGRAM TO THE FILES AREA UNDER THE NAME "EXAMPL" ~ THE NAME GIVEN ON PAGE 113

SEE PAGE 117 ALSO

ONCE IT IS IN THE FILES AREA YOUR PROGRAM WILL NOT DISAPPEAR WHEN YOU SIGN OFF: BUT YOU WILL BE CHARGED RENTAL (USUALLY BY THE DAY) AS LONG AS IT REMAINS IN THE FILES AREA. IT IS ON SUCH RENTALS THAT COMPUTER BUREAUX MAKE THEIR PROFIT.

YOU MAY DISCOVER WHAT YOU HAVE STORED IN THE FILES AREA BY TYPING "CATALOG" (IN BRITAIN YOU MAY TYPE "CATALOGUE"). EVERY SYSTEM PRESENTS THE INFORMATION DIFFERENTLY BUT THE FOLLOWING IS TYPICAL:

```
CATALOG

USER 123021/6     FILES STORED:

NAME       TYPE            SIZE    DATE CREATED
----       ----            ----    ------------
EXAMPL     SOURCE CODE        1    01 MAR   77
PROG27     SOURCE CODE        2    28 FEB   77
DATA65     DATA              27    13 JUN   75
DAT4       DATA              15    24 AUG   72
```



"SOURCE CODE" IS JARGON FOR A PROGRAM IN ITS ORIGINAL FORM ~ IN THIS CASE *BASIC*.

THE MEANS OF CREATING AND STORING FILES OF *DATA* ARE DESCRIBED ON PAGE 120.

"SIZE" DETERMINES THE DAILY RATE CHARGED FOR RENTAL: THE UNITS OF SIZE MIGHT BE *BLOCKS* OR *TRACKS* OR SOME OTHER MEASURE DEPENDING ON THE KIND OF EQUIPMENT IN USE.

COMMANDS (CONTINUED)

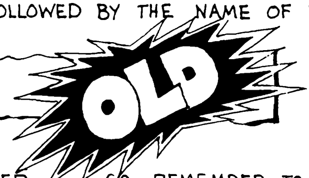
YOU MAY REMOVE A FILE FROM THE FILES AREA — *DESTROY IT COMPLETELY* — BY TYPING "UNSAVE" FOLLOWED BY THE NAME OF THE FILE, OR A LIST OF NAMES SEPARATED BY COMMAS. IN SOME SYSTEMS THE WORD IS "PURGE"; IN OTHERS "DESTROY".

```
UNSAVE DATA65, DAT4
```

IF YOU THEN TYPED "CATALOG" AGAIN YOU WOULD NO LONGER FIND FILES DATA65 OR DAT4 — AND RENTAL CHARGES FOR THEM WOULD CEASE. IN MANY SYSTEMS YOU CAN MAKE COPIES OF FILES ON PUNCHED PAPER TAPE OR PUNCHED CARDS: ON SUCH MEDIA YOU CAN STORE FILES WITHOUT PAYING RENTAL YET HAVE THEM READ BACK INTO YOUR FILES AREA WHEN NEEDED AGAIN. THE MEANS OF DOING THESE THINGS VARY GREATLY FROM SYSTEM TO SYSTEM SO CAN'T BE DESCRIBED IN THIS BOOK.

TO BRING A FILE FROM THE FILES AREA TO THE WORKING AREA YOU TYPE THE COMMAND "OLD" FOLLOWED BY THE NAME OF THE FILE WANTED:

```
OLD PROG27
```



WHATEVER WAS PREVIOUSLY IN THE WORKING AREA HAS NOW DISAPPEARED, SO REMEMBER TO USE "SAVE" *BEFORE* "OLD" IF YOU WANT TO PRESERVE A COPY OF THE WORKING AREA.

YOU MAY NOW TYPE "LIST" IN ORDER TO SEE A COPY OF PROG27, OR YOU MAY TYPE "RUN" TO EXECUTE PROG27, OR YOU MAY TYPE INSTRUCTIONS IN *BASIC* WHICH WILL ADD TO THE PROGRAM OR REPLACE LINES OF IT. WHEN YOU TYPE "OLD" IT IS EXACTLY AS THOUGH YOU HAD *JUST TYPED* THE PROGRAM NAMED. AND THAT PROGRAM DOES, OF COURSE, REMAIN INTACT IN THE FILES AREA: THE COMMAND "OLD" TRANSFERS A *COPY* OF THE NAMED PROGRAM TO THE WORKING AREA.

SO WHAT IF YOU ALTER PROG27 IN THE WORKING AREA BY TYPING SEVERAL NEW LINES OF *BASIC* AND THEN TYPE "SAVE" AGAIN ? THERE IS ONE PROG27 IN YOUR FILES AREA AND A *DIFFERENT* PROG27 IN YOUR WORKING AREA. THE ANSWER IS THAT *BASIC* PRINTS AN ERROR MESSAGE TO SAY THAT PROG27 IS ALREADY SAVED.

HOWEVER, MOST "SAVE" COMMANDS WOULD ALLOW THIS:

```
SAVE   PROG27A
```

IT SAYS "SAVE THE PROGRAM IN THE WORKING AREA *AS THOUGH IT WERE NAMED PROG27A*". YOUR FILES AREA WOULD NOW CONTAIN BOTH PROG27 AND PROG27A; THE PROGRAM IN THE WORKING AREA WOULD STILL BE CALLED PROG27.

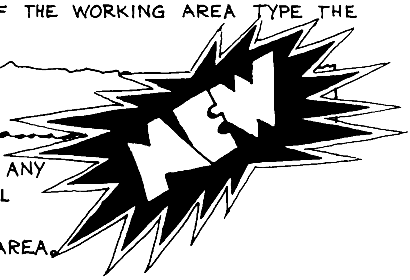
HERE IS ANOTHER SOLUTION TO THE PROBLEM OF DUPLICATED NAMES. THIS ILLUSTRATION SHOWS AN INITIAL ABORTIVE ATTEMPT TO FILE TWO PROGRAMS UNDER THE SAME NAME.

```
SAVE
***ERROR***   PROG27 ALREADY SAVED
UNSAVE  PROG27
SAVE
```

IN MOST SYSTEMS THE COMMAND "UNSAVE" WORKS ONLY ON FILES IN THE FILES AREA — NOT ON THE CURRENT FILE IN THE WORKING AREA. IF YOU NOW TYPED "CATALOG" YOU WOULD FIND PROG27 BACK IN THE FILES AREA BUT ITS DATE OF CREATION WOULD BE TODAY'S DATE.

TO CLEAR EVERYTHING OUT OF THE WORKING AREA TYPE THE COMMAND "NEW".

```
NEW
```



IF YOU DON'T DO THIS THEN ANY LINES OF *BASIC* YOU TYPE WILL GO TO CHANGE THE PROGRAM CURRENTLY IN THE WORKING AREA.

NOTICE HOW THE PROCESS OF SIGNING ON ILLUSTRATED ON PAGE 113 ***FORCES*** THE VERY FIRST COMMAND TO BE:

"OLD" OR "NEW".

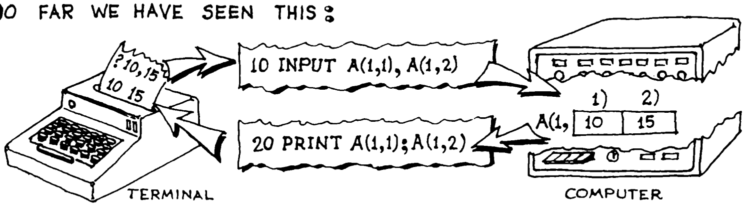
8

FILES OF DATA

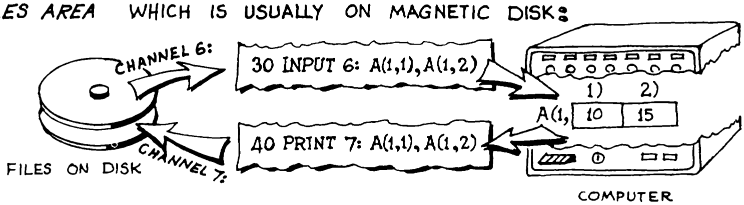
FILES OF DATA

THE KEYBOARD IS NOT THE ONLY MEANS OF INPUT NOR IS THE TERMINAL THE ONLY DESTINATION FOR OUTPUT.

SO FAR WE HAVE SEEN THIS:



BUT YOU MAY ALSO SEND DATA TO AND FROM A *FILE* IN THE *FILES AREA* WHICH IS USUALLY ON MAGNETIC DISK:



FILES ARE NEEDED MAINLY FOR:

- *COMMUNICATION:* RESULTS OF ONE PROGRAM MAY BE STORED IN A FILE FOR SUBSEQUENT USE AS INPUT DATA FOR OTHER PROGRAMS.

- *BACKING STORAGE:* A PROGRAM MAY GENERATE MORE INTERMEDIATE INFORMATION THAN *BASIC* CAN HOLD IN THE FORM OF ARRAYS (EVERY SYSTEM HAS ITS OWN LIMIT ON SIZE OF ARRAY).

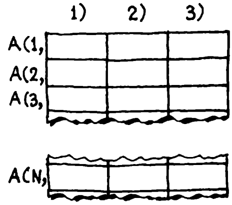
TO TRANSFER DATA BETWEEN ARRAYS IN A PROGRAM AND FILES IN THE FILES AREA USE:

INPUT	(PAGE 18)
MAT INPUT	(PAGE 96)
PRINT	(PAGE 28)
PRINT USING	(PAGE 34)
MAT PRINT	(PAGE 98)

EXCEPT THAT YOU INSERT A *CHANNEL NUMBER* (FOLLOWED BY A COLON) AFTER THE WORD "INPUT" OR "PRINT".

HERE IS A SUBROUTINE TO TRANSFER ROWS 1 TO "N" OF ARRAY A(,) TO A FILE ON CHANNEL 7:

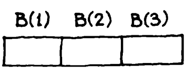
```
1000  REM SUBROUTINE TO TRANSFER N ROWS
1010  REM  OF A(,) TO FILE ON CHANNEL 7:
1020  FOR I = 1 TO N
1030  PRINT 7: A(I,1), A(I,2), A(I,3)
1040  NEXT I
1050  RETURN
```



IF YOU "CALLED" THIS SUBROUTINE A SECOND TIME THE NEW CALL WOULD CAUSE MORE ROWS OF NUMBERS TO BE APPENDED TO THE FILE FOLLOWING THOSE TRANSFERRED IN THE PREVIOUS CALL. THUS YOU CAN STORE AN "ARRAY" IN A FILE MANY TIMES LONGER THAN ALLOWED FOR BY THE "DIM" STATEMENT FOR THAT ARRAY.

HERE IS A SUBROUTINE TO INPUT JUST "RECORD R" FROM A FILE ON CHANNEL 6: . WE ASSUME THIS FILE HAS THE SAME STRUCTURE AS THE FILE ON CHANNEL 7: ILLUSTRATED ABOVE. A FILE IS SIMPLY A STREAM OF SINGLE ITEMS; *YOU* HAVE TO ORGANISE ITS STRUCTURE (SUCH AS *ROWS OF THREE* AS "RECORDS" AS IN THIS EXAMPLE).

```
2000  REM SUBROUTINE TO INPUT SINGLE RECORD
2010  REM "R" INTO B( ) FROM CHANNEL 6:
2020  REM    FIRST RESET FILE TO RECORD 1
2030  RESET  6
2040  REM  WIND THROUGH (R-1) RECORDS
2050  FOR  I = 1  TO  R-1      "WASTE"
2060  INPUT  6:   A,B,C         R-1
2070  NEXT  I                   RECORDS
2080  REM  NOW INPUT RECORD R TO B( )
2090  INPUT  6: B(1), B(2), B(3)
2100  RETURN
```



THIS EXAMPLE ILLUSTRATES THE INSTRUCTION "RESET" WHICH IS COMMON TO MANY *BASICS* ALTHOUGH AT LEAST ONE VERSION USES THE WORD "RESTORE" INSTEAD. YOU ARE USUALLY PERMITTED TO RESET SEVERALS CHANNELS BY A SINGLE INSTRUCTION:

```
100  RESET  1, 3, 6
```

THIS INSTRUCTION MOVES A CONCEPTUAL "POINTER" TO THE BEGINNING OF THE FILE ON THE SELECTED CHANNEL SO THAT THE NEXT "INPUT" INSTRUCTION TO BE OBEYED PICKS UP THE FIRST ITEM IN THE FILE. DO NOT USE "RESET" WHILST *PRINTING* A FILE.

FILE NAMES + CHANNELS

WHEN THERE ARE FILES IN A *BASIC* PROGRAM YOU HAVE TO ASSOCIATE *NAMES* OF FILES AS THEY APPEAR IN YOUR "CATALOG" WITH THE *CHANNEL NUMBERS* USED IN "INPUT" AND "PRINT" INSTRUCTIONS. ("CATALOG" IS EXPLAINED ON PAGE 115.) THERE ARE ALMOST AS MANY WAYS OF DOING THIS AS THERE ARE VERSIONS OF *BASIC*. ASSUMING YOU WANT TO INPUT FROM A FILE CALLED "MYDATA" ON CHANNEL 6: AND PRINT A FILE CALLED "RESULT" ON CHANNEL 7: HERE ARE JUST A FEW DIFFERENT WAYS DIFFERENT *BASICS* REQUIRE YOU TO DO IT. (NAMES YOU INVENT ARE USUALLY LIMITED TO ABOUT 6 LETTERS AND DIGITS OF WHICH THE FIRST MUST ALWAYS BE A LETTER.)

```
10    FILE #6:  "MYDATA"
20    FILE #7:  "RESULT"
```

N.C.C. "STANDARD BASIC"

```
10    FILES #6 = "MYDATA", #7= "RESULT"
```

CASSETTE FILES NUMBERED

DISK FILES NAMED

SIZE IN BLOCKS OF 1024 CHARS.

```
10    FILES 1,2,3,4,5,"MYDATA"/10, "RESULT"/10
```

```
10    FILES A;B;C;D;E;MYDATA;RESULT
```

CHANNELS NUMBERED BY POSITION IN LIST

```
10    OPEN  6 = "MYDATA", INPUT
20    OPEN  7 = "RESULT", OUTPUT
```

INPUT FILES DISTINGUISHED FROM OUTPUT FILES

```
10    OPEN "MYDATA" FOR INPUT AS FILE 6
20    OPEN "RESULT" FOR OUTPUT AS FILE 7
```

```
10    OPEN "MYDATA" TO :6, INPUT
20    OPEN "RESULT" TO :7, PRINT
```

A FURTHER COMPLICATION IS THAT SEVERAL *BASICS* DEMAND YOU FIRST USE THE "JOB CONTROL LANGUAGE" (*i.e.* THE CODE UNDERSTOOD BY THE COMPUTER'S OPERATING SYSTEM) TO DECLARE AND GIVE DETAILS ABOUT ALL THE FILES YOUR *BASIC* PROGRAM REFERS TO: IN SHORT TO GIVE DETAILS TWICE.

FILES (CONTINUED)

YOU CAN FILE TEXTS AS WELL AS NUMBERS :

```
100 REM   FILE NAMES AND DATA
110 PRINT 7: "CUSTOMER'S NAME "; N$; S$
120 MAT PRINT 7: A
```

BUT SOME *BASICS* RESTRICT SUCH MIXTURES OF TEXTS AND NUMBERS TO FILES CODED IN *CHARACTER FORM* AS DEFINED OVERLEAF.

FROM THE PRECEDING EXAMPLES *YOU* WILL APPRECIATE HOW EASY IT WOULD BE TO PRINT A FILE AND GET IT OUT OF PHASE DURING RE-INPUT : REMEMBER YOU CAN'T *SEE* THE CONTENTS OF A FILE. HERE IS A ROUTINE TO INPUT ON CHANNEL 6: THE FILE PRINTED BY INSTRUCTIONS 100 TO 120 ABOVE ON CHANNEL 7: .

```
200 REM   RE-INPUT CUSTOMER'S NAME & DATA
210 INPUT 6:    M$, Q$
220 MAT INPUT 6:   A
```

BUT THERE IS A HORRIBLE BUG. THE TEXT "CUSTOMER'S NAME " WAS PUT ON THE FILE IN FRONT OF THE CUSTOMER'S TWO NAMES STORED IN N$ AND S$: LINE 210 FAILS TO PICK THIS UP, THUS MAKING S$ INTO THE FIRST ITEM OF MATRIX INPUT WHICH IS RIDICULOUS.

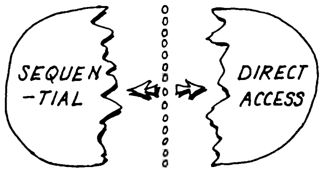
WHEN DEVELOPING PROGRAMS THAT USE FILES IT HELPS TO SEND, SAY, THE FIRST OR LAST ITEM IN EACH TRANSFER TO THE TERMINAL AS A RUNNING CHECK. THE (CORRECTED) DEVELOPMENT VERSION OF THE ROUTINE ABOVE BECOMES :

```
200 REM   RE-INPUT CUSTOMER'S NAME & DATA
210 INPUT 6:   T$, M$, Q$
211 PRINT 210; Q$
220 MAT INPUT 6:   A
221 PRINT 220; A(1,1)
```

LINES 211 & 221 JUST FOR DEVELOPMENT

KINDS OF FILE

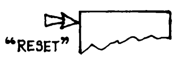
THERE ARE ESSENTIALLY FOUR KINDS OF FILE: SOME *BASICS* OFFER ONLY ONE KIND, OTHERS MORE. HERE IS A ROUGH ANALYSIS:



(OFTEN CALLED *RANDOM* ACCESS)

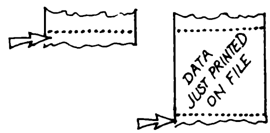
IN THE DOMAIN OF FILES THERE IS A "VERTICAL" DIVISION SEPARATING *SEQUENTIAL* FILES FROM *DIRECT ACCESS* FILES.

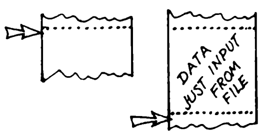
<u>*SEQUENTIAL FILES*</u>



EACH FILE HAS A CONCEPTUAL "POINTER" WHICH STARTS AT THE BEGINNING OF THE FILE AND MAY BE SET BACK TO THE BEGINNING AT ANY TIME BY THE INSTRUCTION "RESET".

WHEN YOU SEND INFORMATION TO THE FILE BY THE "PRINT" INSTRUCTION THE NEW INFORMATION GOES ON THE END OF THE FILE AND THE POINTER MOVES ON JUST PAST THE NEW END THUS CREATED.



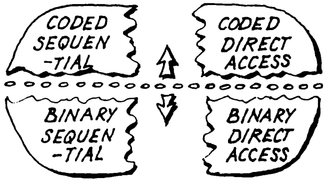


WHEN YOU INPUT INFORMATION FROM A FILE YOU GET THE INFORMATION POINTED TO; THE POINTER THEN MOVES ALONG TO THE NEXT SET OF INFORMATION READY FOR THE NEXT "INPUT" INSTRUCTION.

OBVIOUSLY, THEN, YOU CAN'T "INPUT" FROM A FILE BEING "PRINTED" UNTIL YOU HAVE FINISHED WITH PRINTING AND "RESET" THE CONCEPTUAL POINTER. IN SOME *BASICS* THIS MEANS CLOSING AN OUTPUT FILE AND OPENING IT AGAIN AS AN INPUT FILE; ON THE SAME OR ANOTHER CHANNEL. EXAMPLES ON PREVIOUS PAGES ILLUSTRATE THE USE OF *SEQUENTIAL* FILES.

<u>*DIRECT ACCESS FILES*</u> (THESE ARE OFTEN CALLED *RANDOM* ACCESS FILES: A MISNOMER BECAUSE NOBODY WANTS RANDOMLY CHOSEN RECORDS.) WITH DIRECT ACCESS FILES YOU MAY *CONTROL THE POSITION OF THE POINTER*. WHEN THE POINTER IS IN POSITION YOU MAY TREAT THE FILE AS THOUGH IT WERE A SEQUENTIAL FILE. SO *BASICS* THAT PROVIDE DIRECT ACCESS FILES MUST ALSO PROVIDE SPECIAL INSTRUCTIONS FOR MOVING POINTERS TO "RECORD N" AND FUNCTIONS FOR DISCOVERING WHERE THE POINTER HAS GOT TO. DIRECT ACCESS FILES ARE LESS COMMON IN *BASIC* THAN SEQUENTIAL AND ARE NOT FURTHER COVERED HERE.

THERE IS ALSO A "HORIZONTAL" DIVISION OF THE DOMAIN OF FILES SEPARATING *CODED* FILES FROM *BINARY* FILES.



CODED FILES YOU CAN PRINT THESE AT A TERMINAL OR ON A LINE PRINTER; EVERY LETTER, DIGIT AND SYMBOL IN THE FILE IS UNIQUELY STORED; USUALLY IN A.S.C.I.I CODE. A PROBLEM WITH CODED FILES IS THAT COMPUTERS USING BINARY ARITHMETIC HAVE TO CONVERT NUMBERS FROM CODED DECIMALS TO BINARY DURING INPUT; AND FROM BINARY TO CODED DECIMALS DURING OUTPUT. THIS IS WASTED WORK IF YOU DON'T NEED TO PRINT THE FILE AND READ IT: THERE CAN ALSO BE SOME LOSS OF ACCURACY DURING BOTH CONVERSIONS.

BINARY FILES THESE STORE DATA MORE COMPACTLY THAN IS POSSIBLE WITH CODED FILES AND REQUIRE NO CONVERSION DURING INPUT AND OUTPUT. ON THE OTHER HAND THEY WOULD PRODUCE GIBBERISH IF YOU WERE ABLE TO PRINT THEM AT THE TERMINAL. BINARY FILES ARE STRICTLY FOR STORING INTERMEDIATE RESULTS OF A CALCULATION; AND READING THEM BACK INTO THE COMPUTER FOR FURTHER COMPUTATION. SEVERAL *BASICS* OFFERING BINARY FILES IN ADDITION TO CODED FILES HAVE DISTINCT INSTRUCTIONS FOR BINARY INPUT AND OUTPUT; TYPICALLY:

THE WORD "GET" IN PLACE OF "INPUT"
THE WORD "PUT" IN PLACE OF "PRINT"

AND SOME USE THE WORDS "READ" AND "WRITE" RESPECTIVELY. SOME *BASICS* ALLOW BINARY FILES CONSISTING OF TEXTS. A FEW *BASICS* ALLOW BINARY FILES COMPOSED OF A MIXTURE OF NUMBERS AND TEXTS.

THERE IS NO HOPE OF WRITING COMPLETELY PORTABLE *BASIC* PROGRAMS WHICH USE FILES; BUT IF YOU STICK TO USING *CODED SEQUENTIAL FILES* YOUR PROGRAM SHOULD NOT NEED MUCH ALTERATION TO MAKE IT RUN ON SOME OTHER INSTALLATION.

9

SYNTAX

SYNTAX

THIS IS A SUMMARY OF THE SYNTAX — THE WRITTEN FORM — OF *BASIC* AS DESCRIBED IN THIS BOOK. YOUR VERSION PROBABLY DIFFERS, BUT IF IT HAS A DEFINITION OF SYNTAX SET OUT LIKE THIS ONE THEN MOST DIFFERENCES SHOULD BE EASY TO SPOT BY COMPARISON.

A BASTARDIZED "BACKUS–NAUR" NOTATION IS USED FOR THE SUMMARY. MANY SUCH BASTARDS HAVE BEEN CREATED FOR DEFINING THE SYNTAX OF *BASIC* AND SOME ARE VERY AWKWARD TO READ. I HAVE TRIED TO MAKE THIS ONE AS READABLE AS POSSIBLE WITHOUT LOSS OF RIGOUR BUT EVEN SO YOU MAY FIND IT HARD GOING.

SYMBOLS *IN THE DEFINITIONS.*

⇒	SAYS "IS DEFINED TO BE".
|	SAYS "OR".
[ ]	SQUARE BRACKETS ENCLOSE ANYTHING THAT MAY APPEAR *ONCE* OR *NOT AT ALL* FOR THE DEFINITION TO HOLD GOOD.
{ }	BRACES ENCLOSE ANYTHING THAT MAY APPEAR *ONCE* OR *SEVERAL TIMES* OR *NOT AT ALL* FOR THE DEFINITION TO HOLD GOOD.

PRINTING STYLES *IN THE DEFINITIONS.*

small letters	ARE USED TO GIVE ENGLISH DESCRIPTIONS WHERE THE MATTER IS OBVIOUS OR WHERE THE SPECIAL NOTATION CAN'T REASONABLY COPE.
CAPITALS (+ −/∗↑) <=:;,.$'"> 0 1 2	ARE USED FOR LETTERS, DIGITS AND SYMBOLS WHICH MUST BE COPIED AS THEY STAND TO CREATE A VALID EXAMPLE OF THE THING BEING DEFINED.
Italics	ARE USED TO GIVE NAMES TO THE THINGS BEING DEFINED.

COMMENTS + EXAMPLES.

⦅ ⦆	"SHADOW" BRACKETS ENCLOSE COMMENTS & EXAMPLES WHICH ARE NOT PART OF THE DEFINITIONS.

FIRST THE ELEMENTS OF BASIC : PAGE:

digit ⇒ one of the digits 0 to 9
letter ⇒ one of the letters A to Z
sign ⇒ + | −
operator ⇒ + | − | * | / | ↑ 20
separator ⇒ , | ; 28
comparator ⇒ = | < | > | <= | >= | <> 41
text ⇒ " any characters except quotation marks " 12
line ⇒ an integral line number from 1 to 9999 7
function ⇒ SGN | SIN | COS | TAN | ATN | EXP | ABS | LOG | 22,24
SQR | INT | RND | FN letter
constant ⇒ RND | FN letter 25,26
⟪ THIS DEFINITION ALLOWS BOTH RND AND RND(X); ALSO FNA & FNA(X) ⟫

NEXT THE COMPOUNDS ⟪ ARBITRARILY DISTINGUISHED FROM ELEMENTS ⟫ :

integer ⇒ digit { digit }
⟪ e.g. 0 , 012 , 87654 : LENGTH LIMITED BY PARTICULAR VERSION ⟫
exponent ⇒ E [sign] integer
number ⇒ integer [.] [integer] [exponent] | .integer [exponent] 9
⟪ e.g. 12 , 12.2 , 12.2E+6 , .12E−6 , 12. , 12.E6 ⟫
datum ⇒ [sign] number | text 16
⟪ e.g. 2 , −2.5 , "ABC" AS IN "DATA" STATEMENTS ⟫
variable ⇒ numerical | textual
numerical ⇒ letter [digit] | letter (expression [, expression]) 10,60
⟪ e.g. A, A5, A(4*I), A(I,2*J) ⟫
textual ⇒ letter $ [(expression)] ⟪ e.g. A$, A$(2+I) ⟫ 13,60
lexical ⇒ text | textual 41
⟪ e.g. "ABC" , A$, A$(2+I) AS IN "IF" STATEMENTS ⟫
term ⇒ number | numerical | function (expression) | constant
| (expression) ⟪ e.g. 6.5 , A(I,J), RND, INT(2+B), (−3*I+J) ⟫
expression ⇒ [sign] term { operator term } 20
⟪ e.g. A , + A(I,J) , + A(I,J) * INT(3*A+B) ⟫
declaration ⇒ letter (integer [, integer]) | letter $ (integer) 62
⟪ e.g. A(4) , A(2,30) , A$(26) : AS IN "DIM" STATEMENTS ⟫
printable ⇒ expression | lexical | TAB (expression) 28
⟪ e.g. A(I,J) * INT(ABS(I+P)) , "ABC" , A$(Q), TAB(X) ⟫
adjustment ⇒ (expression , expression) 79
⟪ e.g. (2*A , B(I,J)/6) : AS IN CERTAIN "MAT" INSTRUCTIONS ⟫ P.T.O

SYNTAX (CONTINUED)

NOW THE STATEMENTS OF *BASIC*

SUNDRY:

		PAGE:
line	REM {any character}	8
line	END	7

CONTROL:

		39
line	GO TO *line* ("GOTO" USUALLY PERMITTED)	40
line	GO SUB *line* ("GOSUB" USUALLY PERMITTED)	52
line	RETURN	52
line	ON *expression* GO TO *line* {, *line*}	46
	(WATCH OUT FOR DIFFERENT FORMS OF THE ABOVE)	
line	IF *expression comparator expression* THEN *line*	41
line	IF *lexical comparator lexical* THEN *line*	41
	("GO TO" IS COMMON IN PLACE OF "THEN")	
line	FOR *letter* [*digit*] = *expression* TO *expression* [STEP *expression*]	48
line	NEXT *letter* [*digit*]	48
line	STOP	42

FILE MANAGEMENT: 119

(TOO DIVERSE FOR DEFINITION HERE)

COMMANDS: 111

RUN	114
LIST	114
CATALOG[UE]	115
SAVE [*file*]	115,117
UNSAVE *file*	116
OLD *file*	116
NEW	117

file ⇒ file name with syntax local to the installation

(COMMANDS DIFFER WIDELY IN NUMBER AND SYNTAX AMONG INSTALLATIONS OFFERING *BASIC*)

INDEX

(CONTINUED)

(*CONTINUED*)

INDEX (CONTINUED)

TO MAKE A COMPUTER DO A CALCULATION – HOWEVER SIMPLE – YOU MUST DESCRIBE EVERY STEP OF THAT CALCULATION IN A *LANGUAGE* THE COMPUTER CAN UNDERSTAND: THIS DESCRIPTION IS CALLED A *PROGRAM*. THIS BOOK PRESENTS A POPULAR AND WIDELY AVAILABLE LANGUAGE CALLED *BASIC* AND EXPLAINS HOW TO WRITE SIMPLE PROGRAMS IN IT.

BASIC WAS BORN IN AMERICA AT DARTMOUTH COLLEGE, NEW HAMPSHIRE, IN 1964 AS A SIMPLE COMPUTER LANGUAGE FOR BEGINNERS. IT PROVED POPULAR AND HAS BEEN COPIED AND EXTENDED BY MANY COMPUTER MAKERS, COLLEGES, UNIVERSITIES AND "TIME SHARING" SERVICES. NOW, LIKE ENGLISH, *BASIC* HAS *DIALECTS*: A PROGRAM WRITTEN IN ONE IS UNLIKELY TO WORK ON A COMPUTER COMMITTED TO ANOTHER.

IN WRITING THIS BOOK I HAVE KEPT AT MY SIDE ELEVEN MANUALS – EACH DEFINING A DIFFERENT *BASIC*. FROM THESE I HAVE TRIED TO DISCOVER AND POINT OUT WHERE *BASICS* COMMONLY DIFFER FROM ONE ANOTHER AND RECOMMEND WAYS OF AVOIDING DEPENDENCE ON ANY ONE PARTICULAR VERSION. I HAVE USED THE WORD "PORTABLE" TO DESCRIBE A *BASIC* PROGRAM WRITTEN WITH INDEPENDENCE IN MIND – AND TREAT THE NEED FOR INDEPENDENCE AS AN AXIOM.

YOU DON'T HAVE TO BE A COMPUTER SCIENTIST TO READ THIS BOOK: IT IS WRITTEN FOR STUDENTS MEETING COMPUTERS FOR THE FIRST TIME; FOR THOSE IN INDUSTRY (PARTICULARLY ENGINEERS) WHO NEVER FORMALLY STUDIED COMPUTING BUT WOULD LIKE TO WRITE SIMPLE COMPUTER PROGRAMS; FOR MANAGERS WHO DO NOT WANT TO WRITE PROGRAMS BUT WOULD LIKE TO KNOW MORE ABOUT A FIELD IN WHICH THEY OFTEN HAVE TO TAKE DECISIONS; AND FOR THOSE WHO CAN ALREADY WRITE IN *BASIC* BUT SEEK A BROADER VIEW OF "PORTABLE" PROGRAMMING AND AN INTRODUCTION TO A FEW PROGRAMMERS' TECHNIQUES LIKE "STATE TABLES" AND "LIST PROCESSING".

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